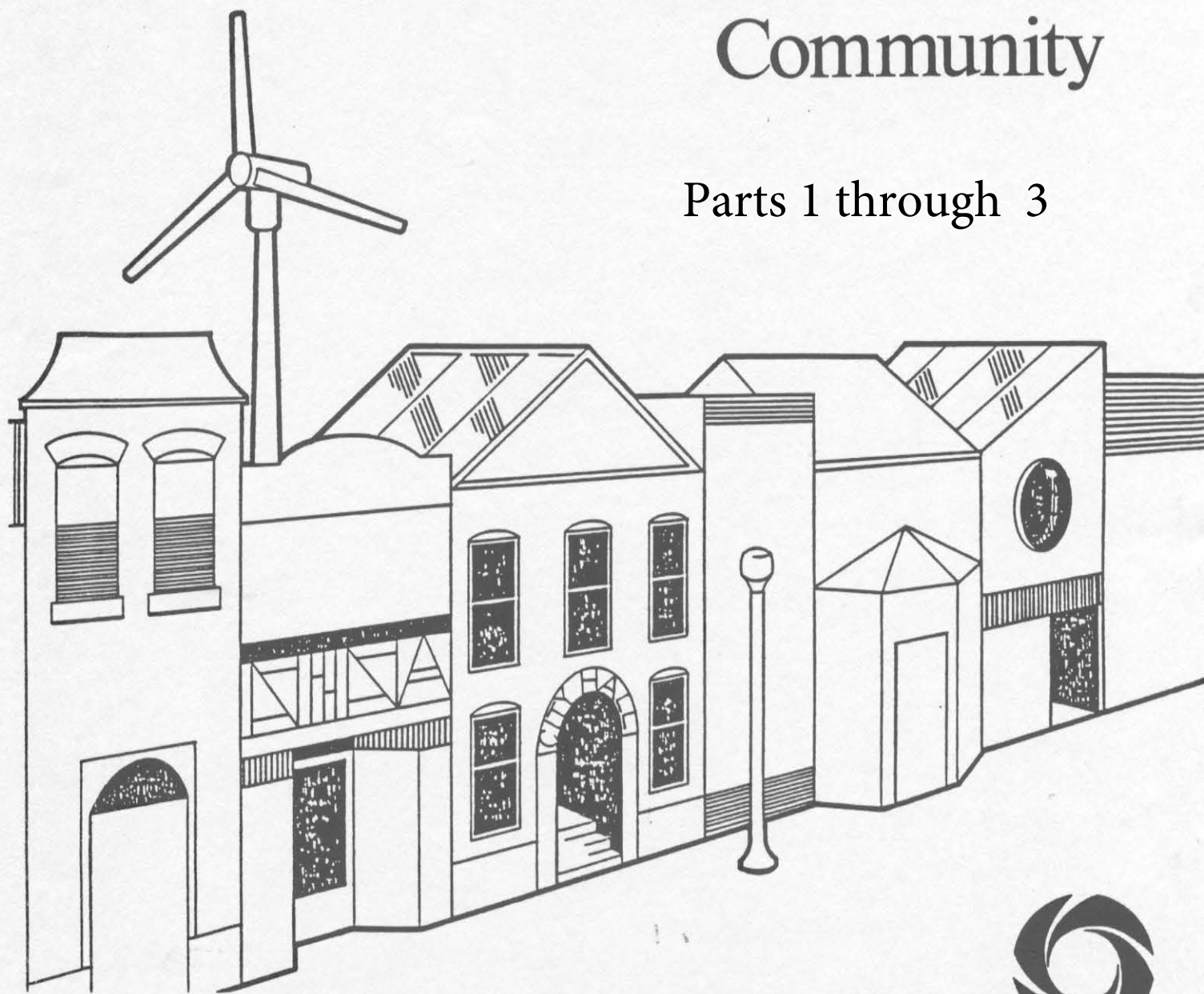


Planning the Energy Efficient Community

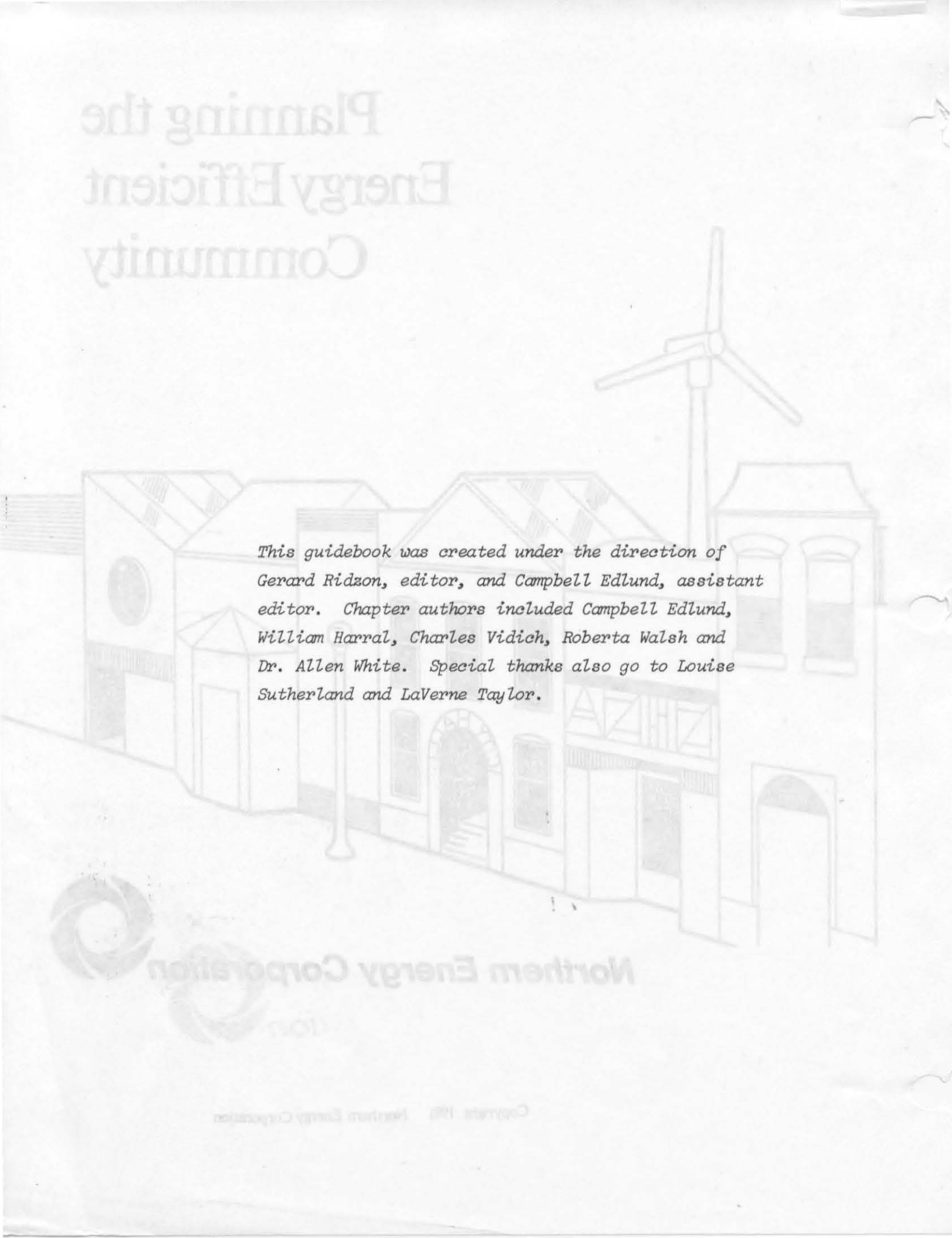
Parts 1 through 3



Northern Energy Corporation



Planning the Energy Efficient Community



This guidebook was created under the direction of Gerard Ridzon, editor, and Campbell Edlund, assistant editor. Chapter authors included Campbell Edlund, William Harral, Charles Vidich, Roberta Walsh and Dr. Allen White. Special thanks also go to Louise Sutherland and LaVerne Taylor.



Northern Energy Corporation

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INTRODUCTION

Energy, long a critical issue at the national and international levels, has emerged as a key issue at the state and local levels as well. Spiraling energy prices and uncertain energy supplies have joined taxes, crime, housing and education as issues confronting local elected officials, administrators, planners and their constituents.

The case for local involvement in energy management is compelling in several respects. First, local jurisdictions represent relatively homogeneous populations capable of identifying energy options and developing policies, programs and projects to realize the most promising alternatives. This commonality of interest distinguishes local jurisdictions from state and federal governments where divergent views can be more difficult to reconcile.

Second, local energy initiatives offer the opportunity to retain community dollars to enhance the economic well-being and employment opportunities for all population sectors. In the Northeast, for example, an estimated 98% of all dollars spent on energy purchases in many smaller dependent communities leave the local economy. Conservation and renewable energy production can reduce this loss of local revenue, allowing dollars previously exported to be reinvested in the local economy, thereby increasing business activity and net disposable income. Some observers estimate that conservation and renewable energy industries create 2-4 times as many jobs per dollar spent as conventional energy industries,² while requiring less capital investment per employee.³

Third, the fiscal health of local government can be enhanced through aggressive energy planning. Cost savings in government operations - city hall, schools, social service centers, municipal vehicles - can reduce the inflationary pressure on local budgets and contribute to full supply stability. Furthermore, municipalities engaged in energy production from

municipal waste, hydropower and wind can benefit from the revenues generated from such enterprises. Finally, one can point to a link between energy-efficient structures, increased property values and, ultimately, increased property tax yields as a strong incentive to locally-initiated energy programs.

Fourth, municipalities exercise authority in areas critical to achieving energy-efficiency building code regulations and enforcement, mass transit, solid waste disposal, zoning and land use planning. Within the framework of these and other traditional local functions, major gains toward energy self-sufficiency are achievable.

Energy Efficiency and Land Use

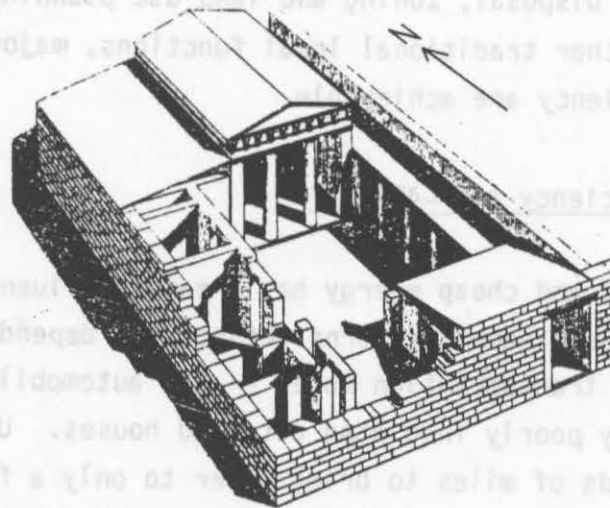
Abundant and cheap energy has greatly influenced our development patterns. Settlement patterns reflect our dependence on one of the most inefficient transportation modes -- the automobile. Our sprawling suburbs are populated by poorly insulated detached houses. Utility lines often stretch over hundreds of miles to bring power to only a few dozen homes. As we look to a future of energy scarcity and escalating prices, decisions made today with respect to housing, land use, economic development and transportation will determine the potential for conservation today and twenty years from now. To realize the benefits of an energy-efficient community tomorrow, energy considerations must become an integral part of the local planning process, today.

Energy-efficient land use planning is not a new idea. Over 2,500 years ago in ancient Greece, where temperatures fell below freezing in winter and rose to uncomfortably hot levels in summer, the Greeks planned their communities and designed their buildings to take maximum advantage of the natural heating and cooling. The basic design principles were described by the philosopher Socrates:

In houses that look toward the south, the sun penetrates the portico in winter, while in summer, the path of the sun is right over our heads and above the roof, so there is shade.⁵

To guarantee that all houses could follow this simple solar design, streets were oriented east-to-west, with the dwelling units oriented to the south. The usually square Greek homes were arranged in block-long rows, sharing common foundations, roofs, and side walls with their neighbors, as illustrated in Figure 1. These shared walls, combined with windowless expanses on the

FIGURE 1

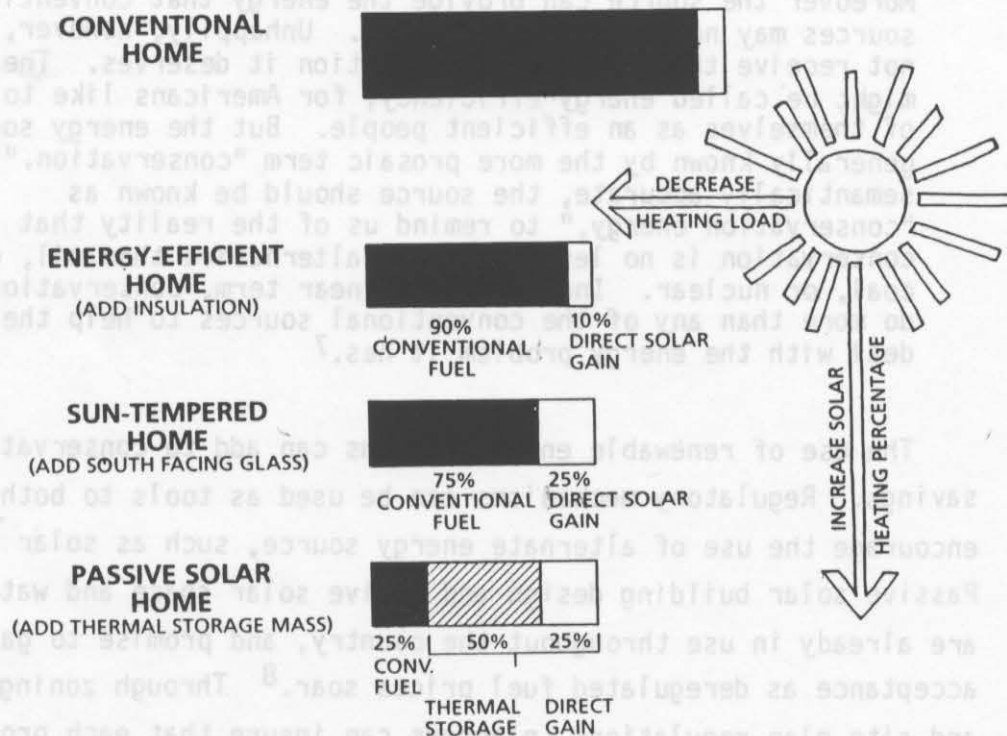


northern exposure, reduced heat loss during the cold months. Winter heat for Greek homes was supplied by the low winter sun, which entered the living area across the south-facing court and through the portico. Earthen floors and adobe walls absorbed and retained this heat, releasing it in the evenings as the air inside began to cool. As Socrates observed, summer cooling was provided by portico overhangs which shaded the living areas from the high summer sun.

Today, the design practices of ancient Greece are more timely than ever. Homeowners throughout the United States are turning to "passive solar design" to reduce fossil fuel consumption. Like their Greek predecessors, passive homes have broad southern exposures, with increased window glazing to optimize solar collection and heating. Porticos have been replaced by roof overhangs to prevent the high summer sun from entering and overheating the home. As illustrated in Figure 2, adding thermal mass in the form of masonry, tile or brick walls and floors (rather than the Greek earthen floors and adobe walls) can reduce heating needs by half. Designers and builders are becoming increasingly aware of the advantages of energy-efficient siting and design.

FIGURE 2

HEATING COMPARISON VARIOUS HOME TYPES



Communities are not only encouraging building in harmony with the environment, but are becoming increasingly aware of the value of energy-efficient urban design. Like the Greeks, communities and developers are orienting streets to guarantee the houses a southern exposure. The energy efficiency of higher density settlement is prompting some municipalities to discourage sprawl. And in part because of lower heating loads, demand is increasing for single-family attached and low-rise multi-family dwellings.

The largest energy "resource" to be harvested from this energy-efficient land use planning is conservation. Although historically not viewed as a resource, observers today recognize it as an alternative whose energy viability at least equals that of conventional fuels. It is estimated that conservation can reduce energy consumption in the United States by 30-80 percent.⁶ The authors of a famous study by Harvard Business School, Energy Future, call conservation "the key energy source":

There is a source of energy that produces no radioactive waste, nothing in the way of petrodollars, and very little pollution. Moreover the source can provide the energy that conventional sources may not be able to furnish. Unhappily, however, it does not receive the emphasis and attention it deserves. The source might be called energy efficiency, for Americans like to think of themselves as an efficient people. But the energy source is generally known by the more prosaic term "conservation." To be semantically accurate, the source should be known as "conservation energy," to remind us of the reality that conservation is no less an energy alternative than oil, gas, coal, or nuclear. Indeed, in the near term, conservation should do more than any of the conventional sources to help the country deal with the energy problem it has.⁷

The use of renewable energy systems can add to conservation energy savings. Regulatory mechanisms can be used as tools to both protect and encourage the use of alternate energy source, such as solar and wind energy. Passive solar building design and active solar space and water heating systems are already in use throughout the country, and promise to gain widespread acceptance as deregulated fuel prices soar.⁸ Through zoning, subdivision and site plan regulations, planners can insure that each property owner has access to the sun. Through regulatory mechanisms developers can be provided with incentives to incorporate renewable energy use into new housing.

Planning the Energy-Efficient Community

The purpose of this guidebook is to assist municipal officials, planners and developers to incorporate energy conservation measures into the land use planning and regulatory processes. It is divided into four sections. Part I, Energy Planning, outlines energy planning principles; suggests implementation strategies, including zoning, subdivision and site plan regulatory mechanisms; provides methodologies for assessing a community's current energy position; and describes selected program options aimed at achieving community energy-efficiency. Part II, Solar Access, discusses measures by which solar access may be insured and renewable energy use encouraged. Part III, Citizen Participation, is designed to provide the basic framework for establishing a community-wide energy program. Such broad based participation is considered to be an essential element to all successful programs in this area. Part IV, Resources, provides renewable energy technology information, bibliographies of sources for further detailed information on energy planning and auditing, and case studies of existing energy planning programs and renewable energy projects.

Through exposure to a wide range of conservation and renewable energy options, we intend to present the reader with an appreciation of the opportunities available for local energy initiatives. For communities with no existing programs, the time is opportune to select and implement a first set of actions which promise short-term, visible results. For communities in which energy initiatives are underway, we hope this document will provide a fresh look at ongoing efforts and suggest additional options to expand the scope of activities. All that follows, we trust, will lend credence to our view that local governments are capable of playing a pivotal role in insuring a viable energy future for themselves and for the nation as a whole.

FOOTNOTES

Introduction

1. Energy Self-Sufficiency in Northampton, Massachusetts, DOE/PE/4706, p. 69. Massachusetts Local Energy Action Program, Arrowstreet, Cambridge, Massachusetts, p. 1. Portland, Maine Neighborhood Energy Strategies, Preliminary Energy Audit.
2. "Jobs and Energy", Council on Economic Priorities, 1979; and Solar Energy and Jobs, Ken Bossong, Local Alternative Energy Futures, Conf-801213-- (Prelim), pp. 365-367.
3. Statistical Abstracts, Bureau of the Census, 1971.
4. Massachusetts Local Energy Action Program, Case Studies, Arrowstreet, Cambridge, Massachusetts.
5. As noted in A Golden Thread by Ken Butti and John Perlier (Palo Alto: Cheshire Books, 1980, page 5) Socrates' comments on the ideal house and found in Xenophon, Memorabilia III, viii.
6. Joel Darmstadter and Lee Schipper. "The Logic of Energy Conservation," Technology Review January 1978, p. 44. Denis Hayes, Energy: The Case for Conservation, Worldwatch Paper No. 4, January 1976.
7. Robert Stobaugh and Daniel Yergin (eds.). Energy Future. New York, Ballantine Books, 1979, p. 167.
8. "Passive Solar Homes are Enjoying a Boom Amid Housing Slump," Wall Street Journal, September 1, 1981, p. 1.

Introduction

THE MASTER PLAN



The first step in energy-efficient planning is to set energy-efficiency as a goal--a deceptively easy task. The master plan provides an ideal framework within which to affirm this goal, since it generally begins with a statement of objectives, principles, and guidelines upon which specific measures for the physical, economic and social development of the municipality are based.

However, simply listing energy conservation as a goal in the master plan will not result in energy savings, unless the methods for accomplishing that goal are also set forth. The goal statement in the master plan should include guidelines, such that the plan can be used effectively as the primary working document for developing energy-efficient land use. A sample goal statement and guidelines provided to Oregon municipalities by the state's Land Conservation and Development Commission (OLCDC) is provided below.¹

ENERGY CONSERVATION

GOAL: To conserve energy.

Land and uses developed on the land shall be managed and controlled so as to maximize the conservation of all forms of energy, based upon sound economic principles.

GUIDELINES:

A. Planning:

1. Priority consideration in land use planning should be given to methods of analysis and implementation measures that will assure achievement of maximum efficiency in energy utilization.
2. The allocation of land and uses permitted on the land should seek to minimize the depletion of nonrenewable sources of energy.
3. Land use planning should, to the maximum extent possible, seek to recycle and re-use vacant land and those uses

which are not energy efficient.

4. Land use planning should, to the maximum extent possible, combine increasing density gradients along high capacity transportation corridors to achieve greater energy efficiency.
5. Plans directed toward energy conservation within the planning area should consider as a major determinant the existing and potential capacity of the renewable energy sources to yield useful energy output. Renewable energy sources include water, sunshine, wind, geothermal heat and municipal, forest and farm waste. Whenever possible, land conservation and development actions provided for under such plans should utilize renewable energy sources.

B. Implementation:

1. Land use plans should be based on utilization of the following techniques and implementation devices which can have a material impact on energy efficiency:
 - a. Lot size, dimension and siting controls;
 - b. Building height, bulk and surface area;
 - c. Density of uses, particularly those which relate to housing densities;
 - d. Availability of light, wind and air;
 - e. Compatibility of and competition between competing land use activities; and
 - f. Systems and incentives for the collection, reuse and recycling of metallic and nonmetallic waste.

One of the municipal energy conservation policies that resulted from OLCDC guidance is that of Portland, Oregon. The text of which is reproduced below. This policy statement is supported by a 70-page support document which outlines the rationale and implementation strategies for each of these energy conservation goals, and by a city energy ordinance adopting the policies outlined in the plan. (A copy of this ordinance is included in Part IV, Resources.)²

ENERGY

The following goal and policies were adopted by the Portland City Council, Ordinance No. 148251, on August 15, 1979, as the **Energy Conservation Policy for Portland**.

GOAL:

- 7 To increase the energy efficiency of existing structures and the transportation system of the city through policies and programs which encourage conservation of nonrenewable resources and the application of renewable resources, while maintaining the attractiveness of the city as a place to live and do business.

POLICIES:

7.1 The Role of the City in Energy Conservation

The role of the City is to ensure the accomplishment of the Goal. All of the energy policies are to be policies of the City and depend on City action. The City shall implement conservation actions directly within City government and shall encourage conservation actions by the private sector. This shall be accomplished through education, incentives, and mandatory actions. The City's efforts shall include promoting conservation; informing all sectors of available programs and conservation techniques; developing financial incentives advocating the support of the City efforts at the state, regional, and federal levels; and regulating conservation actions where appropriate. The City shall evaluate indicators of energy consumption to assure the effectiveness, comprehensiveness and fairness of private sector actions.

7.2 Retrofit of Existing Buildings and Equipment

All buildings in the city shall be made as energy efficient as is economically possible as determined by costs of conservation actions and price of energy. The retrofit of existing buildings for the purpose of energy conservation shall be accomplished through voluntary actions initially, with mandatory requirements imposed five years after the adoption of the policy. Retrofit programs and the requirements must be cost-effective, comprehensive, and have the most equitable impact possible on all sectors of the community.

7.3 Land Use

The City shall develop land use policies which take advantage of density and location to reduce the need to travel, increase access to transit, and permit building configurations which increase the efficiency of space heating in residences. The body charged with providing public transportation should develop routes to take advantage of City land use policies and provide service accordingly.

7.4 Renewable Resources and Alternate Energy System

The consumption of nonrenewable resources for residential and business use shall be reduced by encouraging the application of renewable and alternative energy sources.

7.5 Transportation

The consumption of nonrenewable fuels for transportation shall be reduced through actions which increase the efficiency of the transportation system operating within the city. These actions will encourage individuals to choose the method of travel which is the most fuel-efficient for the purpose of the trip; promote the energy-efficient movement of goods; and provide incentives for the use of fuel efficient vehicles.

7.6 City Government

City bureaus shall reduce energy consumption by investing in energy conservation opportunities and changing operational procedures to the most energy- and cost-effective extent possible.

In brief, then, a community's statement of goals and objectives should include at least three items:

- (1) to increase the energy efficiency of existing structures and future development patterns;
- (2) to increase the energy-efficiency of the transportation system;
- (3) to encourage the use of renewable energy resources.

The degree to which this type of energy objective is achieved depends in large part on the supportive guidance contained in the individual elements of the Master Plan. With specific measures in hand, municipal officials will be equipped to undertake initiatives in a wide range of areas which contribute to a community's energy posture. Since transportation accounts for approximately 25 percent of energy consumption and space heating and cooling another 20 percent, and because local government exercises substantial planning and regulatory authority in land use, transportation and housing, Master Plan elements related to these areas are the logical starting points for local action. In addition, municipally operated buildings represent major energy users under local control and subject to substantial savings during the capital improvements planning and operations/maintenance process.

The remainder of Part I of this guidebook is structured around the aforementioned master plan elements. Following a discussion of community audit techniques to establish an energy profile by end-use sector (Chapters 1 and 2), land use policies and their impact on energy-efficiency are examined in Chapter 3. In Chapter 4, the transportation energy in both public and private sector is discussed in the context of modal shifts, occupancy rates, trip length and frequency. Chapter 5 examines the influence of housing type, siting, and building materials on energy consumption. In Chapter 6, opportunities for energy-efficiency in government and community facilities, e.g., schools, hospitals, libraries, public vehicles - are evaluated.

FOOTNOTES

Master Plan

1. Oregon Land Conservation and Development Commission Statewide Planning Goals and Guidelines.
2. Portland Comprehensive Plan, Bureau of Planning, Portland, Oregon, October 1980.
3. Corbin Crews Harwood, Using Land to Save Energy, (Cambridge, Massachusetts: Ballinger), p. 37-39.

Chapter 1

ASSESSMENT



RESOURCE ASSESSMENT

The introductory portions of the conventional municipal master plan is a logical place to introduce an energy dimension into the planning process. Typically concerned with local historical development and physical resources, these elements are appropriate locations to expand the standard inventory to include the full range of indigeneous energy resources available to a community's households, businesses and industries.

Examination of the physiographic soil, topographic geologic and climatic characteristics of an area can be expanded to relate such features to the energy potential associated with each one. Topography and climate, for example, are basic determinants of wind energy and solar thermal potential and can be assessed within that context. Similarly the rate and distribution of population growth directly influences the volume of municipal solid waste and the potential for public transit utilization. Both represent indigeneous energy resources - the first as a source of steam and/or electricity, the second an approach to reducing gasoline consumption. In a similar vein, small unutilized dam sites and waste wood generated by forest products industries are potential contributors to local energy self-sufficiency.

In the following sections, the most prominent local energy resources are identified and placed in the context of the resource assessment element of the master plan. These include: direct solar, wind, wood, hydropower and solid waste. A detailed discussion of the technologies available to convert these primary resources into useable energy may be found in Part IV of this Guidebook.

The standard approach to measuring the availability of direct solar is to estimate the insolation of an area. Insolation is defined as the quantity of solar radiation striking a horizontal surface over a given period of time, and is measured in Langleys/days where 1 Langley = 3.69 BTU/square foot. By way of example, insolation data, as well as further information on temperatures and heating degree days (HDD) and cooling degree days (CDD)* is shown in Figure 1-1, "Insolation and Temperature Data for Newark, New Jersey."¹

FIGURE 1-1

Insolation and Temperature Data

	Maximum Daily Temp. °C	Minimum Daily Temp. °C	Average Monthly Temp. °C	Heating Degree Days Base 18.3 °C	Cooling Degree Days Base 18.3 °C	Total Global Radiation kJ/m ²	Global $\bar{K}_T$ Cloudiness Index
Jan	3.61	-4.27	-0.33	578	0	6261.0	0.418
Feb	4.55	-3.94	0.33	503	0	9000.0	0.444
Mar	9.33	0.22	4.77	420	0	12582.0	0.457
Apr	16.22	5.66	10.94	221	0	16440.0	0.473
May	22.00	11.16	16.61	79	26	19147.0	0.480
June	27.27	16.44	21.88	0	109	20375.0	0.485
July	29.77	19.55	24.66	0	196	19973.0	0.488
Aug	28.72	18.61	23.66	0	165	17759.0	0.482
Sept	25.00	14.77	19.88	18	65	14446.0	0.474
Oct	19.38	8.94	14.16	135	6	10792.0	0.468
Nov	12.33	3.44	7.88	313	0	6766.0	0.407
Dec	5.27	-2.55	1.38	525	0	5157.0	0.382
Ann	16.94	7.33	12.16	2796	568	13225.0	0.465

	Maximum Daily Temp. °F	Minimum Daily Temp. °F	Average Monthly Temp. °F	Heating Degree Days Base 65 °F	Cooling Degree Days Base 65 °F	Total Global Radiation Btu/ft ²	Total Global Radiation Langleys
Jan	38.5	24.3	31.4	1040	0	551.7	149.6
Feb	40.2	24.9	32.6	905	0	793.0	215.1
Mar	48.8	32.4	40.6	756	0	1108.7	300.7
Apr	61.2	42.2	51.7	398	0	1448.6	392.9
May	71.6	52.1	61.9	142	47	1687.1	457.6
June	81.1	61.6	71.4	0	196	1795.3	487.0
July	85.6	67.2	76.4	0	353	1759.9	477.4
Aug	83.7	65.5	74.6	0	297	1564.8	424.5
Sept	77.0	58.6	67.8	32	117	1272.9	345.3
Oct	66.9	48.1	57.5	243	11	950.9	257.9
Nov	54.2	38.2	46.2	563	0	596.2	161.7
Dec	41.5	27.4	34.5	945	0	454.4	123.3
Ann	62.5	45.2	53.9	5033	1022	1165.3	316.1

STATION NO. 14734

Newark, New Jersey

LATITUDE: 40° 42' N
LONGITUDE: 74° 10' W
ELEVATION: 9 meters (29.5 feet)

*A HDD is defined as the number of degrees the temperature drops below 65°F (18°C). A CDD is the number of degrees above 65°F (18°C) for a single day. The sum of HDD and CDD over a year is a conventional measure of community's heating and cooling requirements.

The amount of insolation an area receives determines in part the feasibility and efficiency of solar systems, both for water and space heating.

Figure 1-2 provides a map of mean daily total radiation in the Northeast. Specific data is available for many cities from the National Weather Service (address included in Part IV, Resources). The total yearly insolation for a community can be calculated by multiplying the average number of Langley's per day by 365 days and the number of square feet the community covers:

$$\text{Insolation}_{\text{annual}} = (\text{Average daily}) \times (365 \text{ days/year}) \times (\text{Community Area in Square Feet})$$

FIGURE 1-2

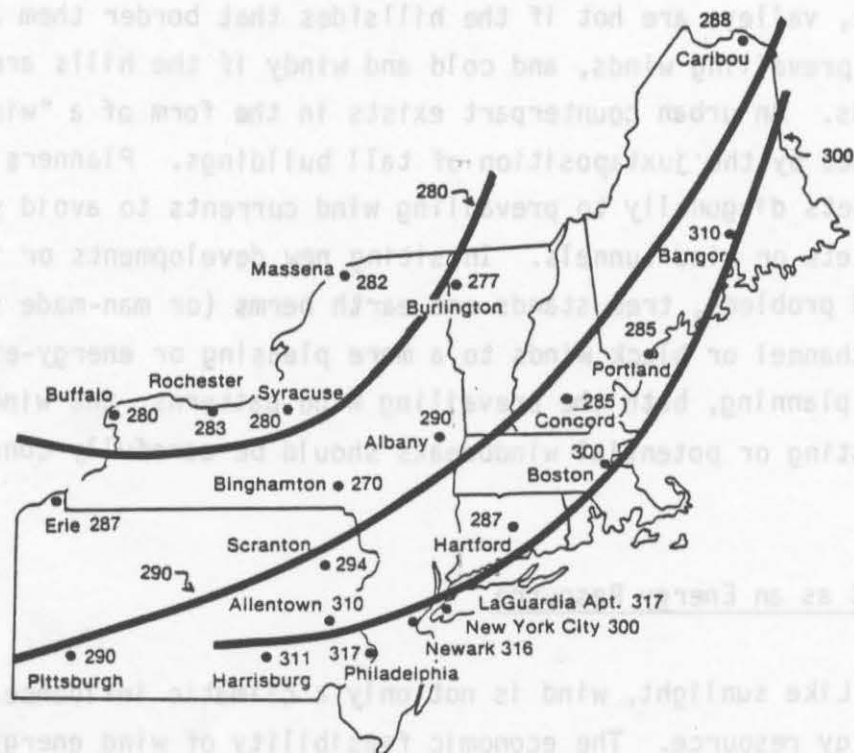


Figure 1b. Mean Daily Total Radiation for the Northeast (Langley's) annual. (Values based on SOLMET rehabilitated and regression estimated data) 1 Langley = 3.69 BTU/FT²

However, insolation is not uniformly distributed over an entire community. In considering site and neighborhood plans, the warmer microclimate of southern slopes should be favored. Northern slopes not only receive less insolation, but are also subject to cold prevailing northern winds and downdrafts. The amount of usable insolation also can be decreased by tall buildings and evergreens used as street trees which can shade other structures.

Effective insolation is also tempered by local wind conditions and topography. In cold weather, the "wind-chill factor" can dramatically increase heating needs. In the Northeast region of the country, northerly winds prevail during the winter months while summer winds are largely south/southwest. Micro-level wind patterns are shaped largely by topography, both natural and man-made. For example, hillsides are often more temperate than their neighboring valleys, because winds blow through a hillside's airspace, but are trapped in the air pocket in the lower valley. As a general rule, valleys are hot if the hillsides that border them are perpendicular to the prevailing winds, and cold and windy if the hills are parallel to the winds. An urban counterpart exists in the form of a "wind tunnel" effect formed by the juxtaposition of tall buildings. Planners should site new streets diagonally to prevailing wind currents to avoid stuffy "deadwind" pockets or wind tunnels. In siting new developments or in solving existing wind problems, tree stands and earth berms (or man-made structures) can serve to channel or block winds to a more pleasing or energy-efficient end. In land use planning, both the prevailing wind patterns, the wind microclimate, and existing or potential windbreaks should be carefully considered.

Wind as an Energy Resource

Like sunlight, wind is not only a climatic influence, but also a renewable energy resource. The economic feasibility of wind energy conversion systems (WEC's) depends greatly on the local wind speeds. Generally, an average annual wind velocity of 10-12 miles per hour is needed to run a wind system economically. A map of the annual average wind power in the Northeast is provided in Part IV, Resources. While such maps are useful starting points, local topography causes great variation in wind potential over a small area.

Wind speeds also vary daily and seasonally. As a general rule, wind velocity tends to be highest along coastal peninsulas and on exposed ridges and summits. At sites where wind data has not been collected, vegetation can often provide a clue to prevailing wind direction and speed.² In all instances, identifying the most promising sites for WECs within a community requires systematic monitoring of wind speed and variability across a number of locations. Further information on evaluating the feasibility of WECs including available technologies, economics, barriers and incentives, is provided in Part IV, Resources.

Wood

Prior to the widespread utilization of fossil fuels, wood served as one of the nation's most important sources of space heating and steam. For most of the last century and into the 1900's wood utilization lost ground to coal, oil and gas, all of which offered distinct advantages in terms of transportability, versatility and cost. Since the early 1970's, however, wood fuels have experienced renewed interest as a result of escalating costs and supply uncertainties associated with oil and gas. As a residential, commercial and industrial fuel, wood offers a viable renewable alternative worthy of community attention.

The wood resource can be considered in four parts:

- the standing stock of wood in the forest (not being used for other purposes, including wildlife preserve, timber pulp or paper industry harvesting)
- the annual growth of the forest
- wood wasted in existing harvesting operations
- wood residue from manufacturing

The U.S. Forest Service continuous forest inventory provides data on the availability by state of each of these sources. The amount of energy that can be obtained from wood varies with its species, condition (amount of decay), and moisture content.³

Because of air pollution from fireplace and stove emissions, some observers believe that widespread residential use of should not be encouraged as a community energy-saving strategy in high-density urban and suburban areas. However, technological advances in residential wood-burning--e.g., gasification, pellets, high temperature/storage systems--are likely to reduce the levels of emissions. Industrial and commercial wood applications, particularly in facilities with their own woodwaste supplies (i.e., firms in the paper, furniture or pulp industries), are generally more efficient and cleaner burning than residential wood uses.

Hydropower

Like wood energy, hydropower was a much more widespread source of energy in the previous century. It now accounts for between 13 and 15 percent of all electricity generated in the United States⁴. Though potential for large-scale hydroelectric facilities in the Northeast is virtually non-existent, many possible locations for small-scale, low-head small-scale hydropower installations do exist.

A quantitative estimate of the development potential of new hydropower must account for the existing use of many sites for water supply, flood control, recreation, or fishery management roles. Multiple uses, of course, provide the opportunity for continuation of these functions in addition to electric power generation.

Hydro installations generally are classified by three characteristics

- low- versus high-head dam site
- small- versus large-scale generating capacity
- run-of-river versus storage reservoir operation

"Head" refers to the "height" of a dam--in other words, the distance the water falls before running the turbine. Most abandoned or undeveloped sites in the Northeast are low-head sites (less than 50 feet in height). To analyze the feasibility of a low-head hydro site, a planner must know the flow rate of a

river (measured in cubic feet per second), and the head. These figures are available from the U.S. Geological Survey. To calculate the power available from a hydro site, the following formula may be used:

$$\text{Power (in kilowatts)} = \frac{\text{river flow} \times \text{head} \times \text{efficiency of turbine}}{11.8}$$

For undeveloped sites a single measurement may be undertaken by the municipality, leaving more in-depth studies to qualified engineering firms. Communities also should recognize that recent federal legislation requiring utilities to purchase power from small producers has converted many financially marginal projects into viable ones. This can place the municipality in a position of power producer and add an important source of revenues to its operations.

Finally, the renovation of abandoned damsites, by virtue of its characteristic central location, can serve as a catalyst to revitalization of the central business districts, including the mill structures contiguous to the site. The power generated at the site can form an integral part of a commercial redevelopment project, taking advantage of federal and state subsidies which encourage such efforts.

Solid Waste

Only during this decade has the energy potential of municipal solid waste (MSW) become fully appreciated by local government officials and private sector entrepreneurs. This new role for what historically was regarded as a public nuisance is attributable to three concurrent developments: (1) the exhaustion of existing and the scarcity of new landfill sites; (2) escalating costs of conventional fuels; and (3) federal and state incentives for small scale energy recovery projects. Today, the generation of steam and

electricity in facilities fueled by solid waste offers municipalities the twofold advantage of alleviating landfill siting and management and, if properly managed, providing a source of municipal revenue.

Solid waste is produced at a rate of 2-4 pounds/person/day depending on the season, local economy and legal environment. The typical waste stream (in tonnage) consists of 37 percent paper, 13 percent glass and 12 percent metals, with the remainder composed of plastics, rubber, textiles and food wastes. Containers and packaging contribute most (42 percent) while newspapers, books, magazines, appliances and furniture also represent major sources.

In New England alone, 49 million/tons/day of waste are generated with an energy equivalent of about 13 millions barrels of oil per year. In more familiar terms, a ton of municipal waste has the heat value of about 1.4 barrels of residual fuel oil or one-third ton of anthracite coal. In a community of 750,000, the combination of residential, commercial and industrial wastes is sufficient to fuel a steam plant capable of meeting the demands of a moderate size manufacturing facility. If properly planned and implemented, such a facility can make a major contribution to controlling energy costs for a major local employer, reduce landfill pressures and earn the local government an attractive rate of return. These are the proven or projected outcomes of communities such as Auburn, ME, Durham, NH, Pittsfield, MA and Windham, CT in which projects are in various stages of operation.

Conclusion

This investigation of local native energy resources, including direct solar, wind, wood, water and solid waste provides an introduction to the wealth of opportunities for local energy self-sufficiency. While the potential of each resource varies across localities, all communities have within their grasp a set of underutilized resources which warrant assessment and exploitation. Local energy development can provide a major ingredient to environmental betterment, economic revitalization and fiscal well-being. The master plan provides a starting point to spurring local initiatives toward achieving these objectives.



FOOTNOTES

Chapter 1

1. C. Knapp, et al., Insolation Data Manual, 1980.
2. E.W. Hewson, J. Wade and R.W. Baker, A Handbook on the Use of Trees as an Indicator of Wind Power Potential, June 1979.
3. The New England Energy Atlas, Dartmouth College Resource Policy Center, Thayer School of Engineering, July 1980, p. 16.
4. An Assessment of Technology for Local Development, Office of Technology Assessment, January 1981 (OTA-R-129), p. 197.

Chapter 2

ENERGY PROFILE



Energy Data Profile

The community energy profile provides a data base for making predictions of energy consumption and developing priorities for energy conservation. Though an effective conservation program must focus on action items--like land use policy changes, zoning revisions, and energy management practices in government buildings--a survey of community energy use provides the requisite information for making well-informed decisions on priorities and feasible options. The community energy profile will serve as a reference in targeting conservation efforts towards different sectors, as well as providing a base for influencing and determining policy alternatives.

The complexity of the data-gathering procedure will depend on the size of the community, the accessibility of information, and the staff time available for research and data compilation. A community energy profile can be prepared in a variety of ways, ranging from a cull of local data from energy studies to a comprehensive energy audit. Even an "armchair audit" requiring a relatively small time investment can provide the necessary understanding of the energy system in a community. The goals, data areas, and methodology outlined below provide alternative approaches to conducting a community audit.

The goal of an energy profile is to develop a readily usable reference on community energy use. This encompasses three tasks:

- Develop a profile of current energy consumption by fuel source -- i.e., fuel oil, natural gas, coal, wood, and gasoline -- and determine energy distribution channels.

- Develop a profile of current energy consumption by user sector -- i.e., residences, businesses, industries, government and vehicles -- and by end-use -- i.e., space heating, air conditioning, water heating and lighting.
- Project future energy use and supply, based on predicted population, economic growth and related variables.

Fuel Sources

The first step--developing a profile of energy consumption by fuel source-- allows the auditor to make judgements with respect to future price increases and supply interruptions. This step also includes identifying supply channels, and ideally, mapping them. The spatial characteristics, the extent of electric, fuel oil and gas service areas may impact on the potential for community energy supply interruptions.

The second step in the community audit -- developing a profile of energy consumption by land use category -- identifies the sector in which the most energy is used and provides the auditor with a sense of how the physical make-up of the community translates into energy use. For example, a community like Atlantic City, New Jersey, with its large population of hotels and entertainment centers, could be expected to have a larger commercial sector energy use than, say, Buffalo, New York, which is highly industrialized. The third step -- projecting future energy use and supply -- is aimed at identifying the likely course of energy supplies and consumption and their community impacts over a given time period. In this guidebook, projection techniques are not covered in detail. Instead, we rely on the straight-line projection common to standard planning procedures. A projection of future energy consumption, assuming no decrease from individual or planned conservation, is made by multiplying current energy consumption figures by measures of population and economic growth. This procedure ignores many variables which impact energy use. It does, however, provide a basis for comparison with scenarios which include conservation through land use planning, energy management and use of renewable energy sources. Clearly, the goal of an energy-efficient master plan is to level off and ultimately reverse the straight-line projection and attendant growth curves characteristic of most communities in the United States.

For communities which can afford the time and expense - or because of their size, require a more complex approach - two well-tested audit methodologies exist: Comprehensive Community Energy Planning developed by Hittman Associates for the U.S. Department of Energy (November 1978) and the County Energy Plan Guidebook, by Okagaki and Benson (July 1979)*. For comparison purposes, below are brief descriptions of the Hittman and Okagaki/Benson methodologies.

Hittman

The Hittman methodology is among the most comprehensive and accurate energy audit methods. Not surprisingly, it also requires substantial time and manpower resources. The methodology consists of four discrete steps:

- Community Energy Audit
- Energy Objectives Formulation
- Identification of Alternatives and Strategies
- Implementation

The Hittman structure is illustrated in the flow chart in Figure 2-1. The Energy Audit, comprising the first major part, is completed by determining the number of units and average square feet per unit for the following land use sectors: residential, commercial/civic/institutional, and government. In the industry land use category, unlike other land use categories where energy used is a function of floor space, the industrial process is the critical factor in energy use. Therefore, the Hittman study categorizes industries by "energy intensity", and suggests using number of employees as the energy use indicator since the size of the operation also affects energy use. In the second part of the Energy Audit, energy use is computed by using Energy Intensity Factors (EIF's) for each community component - which can either be taken from the Hittman study's national averages (Basic Energy Factors or BEF's) or, preferably, developed for each specific community. Thus, as illustrated in the sample worksheet portion in Figure 2-2, the auditor compiles an index of

*It should be noted here that the title of County Energy Plan Guidebook is something of a misnomer, for it can be used as effectively by municipalities, greater urban areas, and region, as it can by counties.

FIGURE 2-1

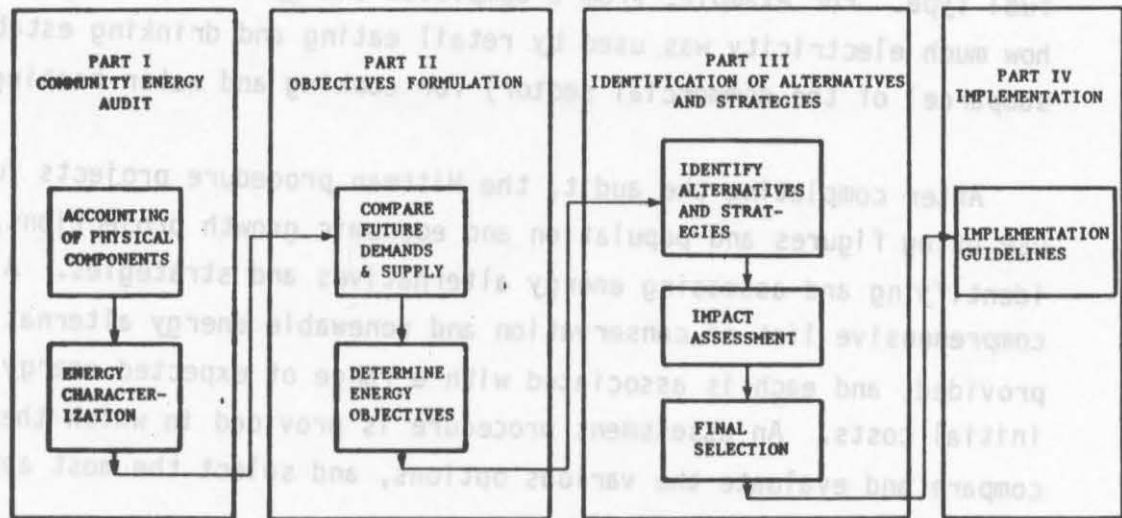


FIGURE 2-2

ENERGY USE CATEGORY			BASE YEAR						FUTURE ADDITIONS				
			FUEL FRACTION (INVENTORY)	BASIC ENERGY FACTOR (BEF)	HDD/ CDD	ENERGY INTENSITY FACTOR (EIF)	NUMBER OF COMMUNITY UNITS	ENERGY USE	PROJECTED ADDITIONAL UNITS	FUEL FRACTION (ADDITIONS)	EEF (ADDITIONS)	EIP (ADDITIONS)	ENERGY USE BY ADDITIONAL UNITS
PARCEL	ACTIVITY	FUEL TYPE	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Eating and Drinking Places	Space Heating	Utility Gas		5.3									
		Pool Oil, Kerosene, Etc.		6.4									
		Coal Or Coke		7.4									
		Electricity		3.7									
		Bottled, Tank, Or L.P. Gas		5.3									
		Residual Fuel Oil		6.4									
		Other (Wood, Steam, Etc.)		7.4									
	Total												
Eating and Drinking Places	Space Cooling	Utility Gas		76.									
		Electricity		19.									
		Other (Steam)		53.									
		Total											
Eating and Drinking Places	Cooking and Water Heating	Electricity		140,000									

energy use by land use sector, land use parcel, energy-using activity, and fuel type. For example, from a completed energy audit, one could determine how much electricity was used by retail eating and drinking establishments (a subparcel of the commercial sector) for cooking and water heating.

After completing the audit, the Hittman procedure projects future energy use using figures and population and economic growth projections, and then identifying and assessing energy alternatives and strategies. A rather comprehensive list of conservation and renewable energy alternatives is provided, and each is associated with a range of expected energy savings and initial costs. An assessment procedure is provided in which the user can compare and evaluate the various options, and select the most appropriate combination for the community.

In Hittman's fourth and last section, implementation strategies are suggested and possible methods of administering an energy management plan are outlined. A copy of the list of "Strategies and Alternatives" outlined in Hittman is included in Part IV, Resources, of this guidebook. This list can be useful as a "brainstorming" piece, even without the formulas which determine numerical values for conservation potential and energy savings.

County Energy Plan Guidebook

The County Energy Plan (CEP) is structurally similar to the Hittman method through step two, but diverges substantially in the third and fourth. CEP's four major steps are:

- Estimate annual energy consumption in each of the four primary use sectors (residential, commercial, industrial and transportation) and each activity subsector (space heating, space cooling, water heating, etc.).
- Project energy consumption in the year 2000, based on population and economic growth predictions.

- Estimate the amount of energy which could be saved from the year 2000 base figure through "very aggressive" conservation.
- Assess the renewable energy resources, and their potential to supply energy to each of the subsectors.

The last two steps are summarized by CEP's authors: "Working from the year 2000 projection, you cut down the energy needs as much as possible through conservation, and then try to fill the remainder using renewable energy resources."¹ Clearly, CEP's approach derives from a commitment to conservation and renewables most lucidly articulated by Amory Lovins.² While one may contest the philosophical underpinnings of the so called "soft energy" approach, it does provide both a rationale and guidance for decentralized initiatives which are particularly suitable for local governments.

One distinct advantage of the CEP audit over the Hittman audit is its simplicity. It provides "ballpark" figures for sectoral energy consumption which for most communities is more than adequate to provide a basis for decision-making. In Figure 2-3, the sample CEP worksheet illustrates the relative simplicity of this approach as well as the sectoral/energy activity framework identical to the Hittman approach.

From the audit results, energy use for the year 2000 is calculated simply by multiplying current energy use by the ratio of the projected year 2000 population by the current population (for residential and transportation sectors) or by the ratio of projected year 2000 sales to current sales (for industrial and commercial sectors), as illustrated below:

$$\text{Residential Energy Consumption}_{2000} = \frac{\text{Population in 2000}}{\text{Current Population}} \times \text{Current Residential Energy Consumption}$$

AND

$$\text{Commercial Energy Consumption}_{2000} = \frac{\text{Commercial Sales in 2000}}{\text{Current Commercial Sales}} \times \text{Current Commercial Energy Consumption}$$

FIGURE 2-3

TALLY SHEET 1

County Energy Consumption Profile

Residential Sector

1. Space Heating _____
2. Air-Conditioning _____
3. Water Heating _____
4. Lighting _____
5. Refrigeration _____
6. Cooking _____
7. Clothes Drying _____
8. Other Appliances _____
9. Total End Use Consumption _____
10. Total Electricity Consumption _____
11. Total Primary Energy Consumption _____

Commercial Sector

12. Space Heating _____
13. Space Cooling _____
14. Lighting _____
15. Water Heating _____
16. Cooking _____
17. Refrigeration _____
18. Other _____
19. Total End Use Consumption _____
20. Total Electricity Consumption _____
21. Total Primary Energy Consumption _____

From the audit results, energy use for the year 2000 is calculated simply by multiplying current energy use by the ratio of the projected year 2000 population by the current population (for residential and transportation sectors) or by the ratio of projected year 2000 sales to current sales (for industrial and commercial sectors), as illustrated below:

$$\text{Residential Energy Consumption}_{2000} = \frac{\text{Population in 2000}}{\text{Current Population}} \times \text{Current Residential Energy Consumption}$$

AND

$$\text{Commercial Consumption}_{2000} = \frac{\text{Commercial Sales in 2000}}{\text{Current Commercial Sales}} \times \text{Current Commercial Energy Consumption}$$

The straight-line projection Energy Consumption 2000 figures are defined by CEP as the "hard path" figures, and are used as the basis for developing conservation targets, which take into account the cost of energy, the cost of conservation equipment and inflation. These conservation targets are, according to CEP, "the quantities of energy the county (or city) really needs if it pushed toward maximum conservation."⁴ The last step of CEP provides the guidelines for evaluating the potential of renewable energy available in the community to fulfill the remaining energy needs.

Audit Procedure Guidelines

From the audit approaches outlined above, a hybrid format may be formulated.

I. Develop a profile of current energy consumption by fuel source and determine the supply channels through which energy is distributed.

Because information on energy consumption by fuel type is relatively accessible, it is a logical first step for the planner. By contacting local energy distributors -- including utilities, fuel oil dealers, gas companies, and petroleum distributors -- an energy analyst can construct a first-hand profile of consumption by fuel type. At the same time, information on distribution channels can be gathered. Utility and fuel oil or service areas should be mapped, as well as large transmission lines, so the planner will have a grasp of energy flows in the community. Some of this research and mapping may have already been completed under the standard utility services plan element. This information will help determine priorities for future development, since growth into areas not now serviced by utilities and fuel deliveries should be avoided. In addition, it may prove useful if utilities are planning expansion of their generating capacity. In addition to the local utilities, the following sources may have the information:

- Public Service or Utility Commissions

- County Energy Offices

- State Energy Offices

In developing the profile, it is useful to convert all consumption data into one kind of units: Btu's (British Thermal Units) are perhaps the most universal, though some planners will find it more relevant to convert to "barrels of oil/equivalents." Conversion factors are provided in Figure 2-4.

FIGURE 2-4

Thermal Conversion Factors
(in terms of British Thermal Units)

1 Kilowatt hour	=	3,143 BTUs
1 Pound Coal	=	12,500 BTUs
1 Ton Coal	=	24,000,000 BTUs
1 Gallon Residual Oil	=	150,000 BTUs
1 Gallon Distillate Fuel Oil	=	140,000 BTUs
1 Ft ³ Natural Gas	=	1,021 BTU's
1 Therm Natural Gas	=	102,100 BTUs
1 Pound Dry Hogged Wood Fuel	=	8,000 BTUs

Note: 100 Ft³ = 1 Therm

1 Quad or 1 Quadrillion BTUs = 10¹⁵ BTU

1 MBTU or 1 Million BTUs = 10⁶ BTU

Once the fuel-type profile has been developed, it can be compared with national, regional and state standards and trends to identify unusual differences.

At the regional scale, for example, the northeast region is far more dependent on oil than the nation as a whole. Sixty-two percent of the region's energy supply is oil. And sixty-three percent of that oil is imported from abroad. Stated in dollar terms, the Northeast pays \$76,800,000 a day for foreign oil (oil at \$30 a barrel).⁵ Energy profiles for the nine states in the northeast region are found in the resources section. Even at this preliminary stage, a planner can identify a community's dependence on fuel sources, and make early assessments of the direction conservation efforts might take. This fuel source information can also be useful in supporting land use policy changes and additions, as well as in developing and backing up the community energy plan.

		NATIONAL		NORTHEAST	
		(million BTU's)	Percent	(million BTU's)	Percent
Coal		13,943.887	18	1962.176	15
Natural Gas		19,998.907	26	1762.923	13
Fuel Oil		16,663.571	21	4900.735	36
Gasoline		21,301.724	27	3607.878	27
Nuclear		2,976.585	4	863.962	6
Hydro		3,173.000	4	413.125	3
Other		67.877	--	.115	--
TOTAL		78,125.551	100	13510.914	100

Source: Developed from State Energy Data Report, 1960-1978, DOE/EIA-0214 (78).

- II. Develop a profile of current energy consumption by user category, (i.e., residential, commercial, industrial, transportation and government), and by end use (i.e., space heating, air conditioning, water heating, lighting and vehicles).

This second step in the audit provides important information on where and how energy is being used in the community. This information is most helpful in making decisions on where conservation and energy management will have the most impact, as well as assessing which renewable technologies are applicable in the community. When this step is completed, a matrix of information might resemble the one below:

	<u>END USE</u>					
	Total	Space Heating	Air Conditioning	Water Heating	Lighting	Process Heat Other
Residential						Appliances
Commercial						Office Equipment
Industrial						
Transportation						Vehicles
Government						Office Equipment

Unfortunately, this step is also the most difficult in the audit procedure. Energy use data is rarely broken down into user and end use categories by traditional information sources.

In compiling user data (vertical column in the matrix above), utilities are a good place to start for information on energy use in the three standard land use categories. The transportation and government sectors will be treated separately. Depending on its rate structure and billing system, a

utility may break energy consumption data into groups by geographic location, by amount of energy consumed, or by user category. Ideally, the utility in your area is able and willing to provide consumption data assembled by residential, commercial and industrial categories. If information is not available in this form, there are a number of short-cut methods for deriving numbers.

The simplest "guestimation" method is often referred to as the "top-down" approach because it computes community energy use as a percentage of state consumption figures. Energy consumption data by user category is assembled for each state annually by the Energy Information Administration and often by state energy offices. The top-down approach assumes that energy use is in direct relation to the size of the user community. For example, a community's residential energy consumption should be in the same ratio to state residential energy consumption as the community population is to the state population. Similarly, commercial energy consumption can be determined by the local to state ratio of commercial square footage, and industrial energy use by a ratio of total employee population. Expressed in formulae, the top-down approach reads as follows:

(CEC = Community Energy Consumption)

$$\text{Residential CEC} = \frac{\text{Community Population}}{\text{State Population}} \times \text{State Residential Energy Consumption}$$

$$\text{Commercial CEC} = \frac{\text{Community's Commercial Square Footage}}{\text{State's Commercial Square Footage}} \times \text{State Commercial Energy Consumption}$$

$$\text{Industrial CEC} = \frac{\text{Community's Industrial Labor Force}}{\text{State's Industrial Labor Force}} \times \text{State Industrial Energy Consumption}$$

$$\text{Transportation CEC} = \frac{\text{Community's Vehicle Miles Travelled}}{\text{State VMT}} \times \text{State Transportation Energy Consumption}$$

Community Energy Consumption

Key Data Factors

STATE ENERGY USE:

(in Trillion BTU)²

STATE

<u>Sector</u>	<u>MA</u>	<u>MD</u>	<u>NY</u>	<u>PA</u>
Residential	403.8	247.2	1116.5	938.8
Commercial	448.6	212.5	1029.1	654.9
Industrial	237.5	367.5	840.0	1868.5
Transportation	383.5	328.1	1076.8	862.9

RATIO FACTORS:

STATE

<u>Factor</u>	<u>MA</u>	<u>MD</u>	<u>NY</u>	<u>PA</u>
Population	5,689,000	3,933,000	18,237,000	11,794,000
Labor Force	2,364,000	1,529,000	6,827,000	4,550,000
Employees Mfg. Industries	608,000	236,000	1,459,000	1,342,000
Vehicle Miles Travelled	35,178 (Million)	27,835 (Million)	77,810 (Million)	70,286 (Million)

Sources: Northern Energy Corporation, R.W. Mitchell, 1981.
Ratio Factors are from the 1978 Statistical Abstract of the U.S.
Census Bureau.

Motor Vehicle Facts and Figures, 1981, Motor Vehicle Manufacturers
Association. (Statistics cover the year 1979).

Government sector energy consumption varies greatly from community to community, and therefore cannot be estimated by this method. However, because consumption data is available "in-house" in the government sector, a first-hand energy audit is relatively easy to complete, and is discussed in Chapter 6, Government/Community Facilities. Clearly, the numbers derived in

this way will not be as accurate as those collected from empirical data. However, if time does not allow a more comprehensive information-gathering process, this method produces adequate guidelines, particularly in small- to medium-sized communities. If you are constrained to the "shortcut method," percentage figures for energy consumption by end use may be taken from averages, either at the state levels (often available from the state energy office), or at the regional or national level.

A more accurate method for developing a sector-by-end use energy matrix involves hand-collecting most of the data, either through a census process or by windshield survey. This method can of course be interspersed with "guestimates" or existing data where first-hand information proves too time-consuming to ferret out. However, with this method, each sector must be treated individually as outlined below.

- Residential

The amount of energy used in a community's residential sector is clearly dependent on many variables, with climate the single most important. Fortunately, climatological data is readily available in a form usable for residential energy consumption calculations: heating and cooling degree days (HDD's and CDD's), discussed earlier in Chapter 1, Assessment. Specific HDD/CDD figures can be obtained from the National Weather Service for most cities.

Other variables which impact on residential energy consumption include:

- size of dwelling
- number of occupants
- type of building (single-family, multi-family, low-rise, high-rise)
- quality of construction
- age of structure
- age and efficiency of heating system
- existence and quantity of insulation, weatherstripping
- existence of solar design features or solar hardware
- energy "awareness" of occupants

Though these variables cannot all be determined for every house, the better the estimate of their impact, the more accurate the energy profile. As the auditor, you know your community, and can probably judge which of these factors substantially impacts your community's energy consumption. A windshield survey, mail survey, or an in-depth physical survey of a few well-chosen neighborhoods could be used to confirm and support your judgments. Now that you have a qualitative sense for factors impacting energy use, the discussion turns to quantitative analysis.

The first variable to be needed in space heating calculations is square feet of residential space. Ideally, this number would be broken down by type of dwelling unit, i.e., single-family, attached or detached; multi-family, low-rise or high-rise; or mobile home. If residential square footage figures are not available, but number and type of dwelling units are, using average sizes given below, total square footage for each type can be estimated:

Single-family detached	1570 sq. ft.
Single-family attached	1370 sq. ft.
Multi-family high-rise	900 sq. ft.
Multi-family low-rise	900 sq. ft.
Mobile home	700 sq. ft.

Source: Comprehensive Community Energy Planning, Hittman Associates, Vol. II.

To determine the total square footage of each housing type, simply multiply the average size of the type by the number of dwelling units (available either from census data or windshield survey). By multiplying these total square footage figures by average heat loss coefficients for each type, and adding the results, you calculate the total space heating demand for the community's residential sector. Though national average heat loss coefficients, or thermal requirements are provided below, you may feel it

worthwhile to contact local utilities, homebuilders' associations or architects for more locally specific numbers. It is within this heat loss coefficient calculation that other variables listed above -- age of housing, amount of insulation, etc. -- come into play. The heat loss coefficient for a specific house is derived with the following formula:

$$\text{Heat Loss Coefficient} = \frac{\text{\#BTU's used annually for heating}}{(\text{square footage of home})(\text{Annual \# Heating Degree Days})}$$

Averages for the Northeast region are listed in the following table:

<u>Housing Type</u>	<u>Heat Loss Coefficient (BTU/sq. ft-HDD)</u>	
	<u>Existing Construction^a</u>	<u>New Construction^b</u>
Single-family detached	21.9	19.04
Single-family attached	21.1	6.40
Multi-family low-rise	15.1	4.80
Multi-family high-rise	14.0	2.85

a Source: Arthur D. Little, Inc., Project Independence, 1974, based on 1970 inventory.

b Source: Hittman Associates, Residential Energy Consumption Detailed Geographic Analysis. Summary Report, May 1977, based on 1974 construction survey.

Once these heat loss coefficients are obtained, the following equation is used to determine total residential space heat requirements (R_{SH}) for each dwelling type category in the community:

$$RSH_{SH} = \frac{\text{Heat Loss Coefficient} \times \text{Total Square Footage} \times \text{Heating Degree Days}}{1}$$

This calculation is completed for each housing type. The sum of the results provides a figure for total residential space heat consumption in the community.

Clearly, space heating uses only a part of the total residential energy consumed. Air conditioning is also an energy user, though its aggregate contribution to energy consumption totals is more difficult to determine because every house does not have air conditioning. Moreover, central air conditioning uses far more energy than one-room air conditioners or window units. A possible source of information is the "Selected Electrical Appliances" section of the census of Detailed Housing Characteristics, which reports numbers of homes with room air conditioners within Standard Metropolitan Statistical Areas (SMSA's). If your community is not within an SMSA, you might choose to use figures for the nearest one if your climate is similar, remembering that, in general, urban areas require more cooling than less densely populated areas. Or you might contact local HVAC (Heating, Ventilation and Air Conditioning) distributors or trade groups who may have surveys or estimates of the number of homes with air conditioning units. Once you have an estimate for the number of homes with air conditioning, the calculation of total residential space cooling energy requirements (R_{CS}) is similar to the space heating calculation above. Determine the square footage of floor space cooled by such units, and multiply it by the cooling demand (equal to the number of Cooling Degree Days), and air conditioner efficiency (which is given a value of 10/ft²/CDD nationally -- again, local HVAC dealers may have more localized figures). This calculation is expressed in an equation as follows:

$$R_{SC} = \frac{\text{Total Residential Square Footage} \times \text{Annual Cooling Degree Days} \times \text{Conditioner Efficiency}}{1}$$

To determine the energy consumption for other end uses, including water heating, cooking and running appliances, simply multiply the number of occupied dwelling units by the energy requirements for each appliance listed below. This method will not produce completely accurate results because not every family has a clothes washer or a dishwasher. Community-specific figures on how many dwelling units do include such amenities, should be used whenever available. In addition, single-family dwellings typically have higher appliance energy consumption than multi-family dwellings which house fewer residents per unit.

Average Annual Household

End Use Consumption

End Use	Single Family	
	kwh/hr.	Million Btu/yr.
Water Heating	8,357	28.5
Lighting	908	3.10
Refrigerator (frost free)	1,600	5.46
Range (electric)	1,200	4.10
Dishwasher	300	1.02
Clothes Washer	100	0.34
Clothes Dryer	1,000	3.41
Color TV	500	1.71
Other Miscellaneous	700	2.39
Clock	(12)	
Coffee Maker	(144)	
Food Blender	(12)	
Hair Dryer	(24)	
Iron	(156)	
Radio	(84)	
Toaster	(20)	
Vacuum Cleaner	(72)	
Sewing Machine	(12)	
Other	(164)	

Source: Portland Energy Conservation Choices, Volume 3A, p. 16.

Thus a sample calculation for annual water heating energy would be:

$$R_{WH} = (\# \text{ dwelling units total}) (28.5 \text{ MBTU})$$

Or for television energy consumption:

$$R_{TV} = (\# \text{ Dwelling units with TV}) (1.71 \text{ MBTU})$$

Utilities sometimes collect statistics on the per-household energy consumption for each of these subsectors. If these locally specific figures are available, substitute them for the national averages.

The sum of the results of these three calculations - space heating, space cooling and appliance/water heating energy consumption - represents total residential energy consumption in your community.

● Commercial

The commercial sector contains perhaps the greatest diversity in terms of types of establishments, and is therefore difficult to handle in an energy audit without collecting data first-hand. The commercial/institutional sector includes the following sub-sectors:

- Retail
 - Food stores
 - Eating and drinking establishments
 - General merchandise
 - Other retail and services
- Wholesale
- Office
- Hotel/Motel
- Auditoriums and Arenas
- Movie Theatres
- Hospitals, Nursing Homes
- Parking
- Terminals
- Religious/Social
- Cultural/Museums

Short of completing a full-fledged data collection effort, one of the best options for dealing with the commercial sector energy audit is to use previously developed average figures for energy use, either per employee or per square foot. Many studies on office space energy use have been completed. One is shown in the following analysis:

COMMERCIAL ENERGY PROFILE

Office Space in the Northeast Region
(5500 Heating Degree Days/1200 Cooling Degree Days)

End Use Demand (per Sq. Ft.)

	<u>000's BTU</u>	<u>Percent of Total</u>
Space Heat	83	53
Air-conditioning	42	27
Lighting	22	14
Misc. Electrical	10	6
	157 thous. BTU/Sq. Ft.	100%

Source: Planner's Energy Workbook, T. Owen Carroll, BNL-50633, p. 29.

Unfortunately, office space is only one of a myriad of uses which fall under the commercial characterization. A broader set of averages is provided by estimates for BTU's used per employee were made by Skidmore, Owings Merrill in the course of a municipal energy audit for Portland, Oregon. These estimates are particularly useful, as numbers of employees are often more available than square footage of different commercial establishments:

SECTOR	Million BTU's used per job
Retail and Wholesale Trade	115
Services (Hotels, Medical, Recreational buildings, etc.)	133
Finance, Insurance, Real Estate, Communications	51
Large Office Small Office	45

Source: Portland Energy Conservation Choices, Volume 3C, p. 18.

Using these estimates, total commercial energy consumption can be calculated by multiplying BTU's/job by the number of jobs in that sector, often available from census data or a local chamber of commerce or trade group. These figures are only estimates, and should not be considered definitive computations of energy use.

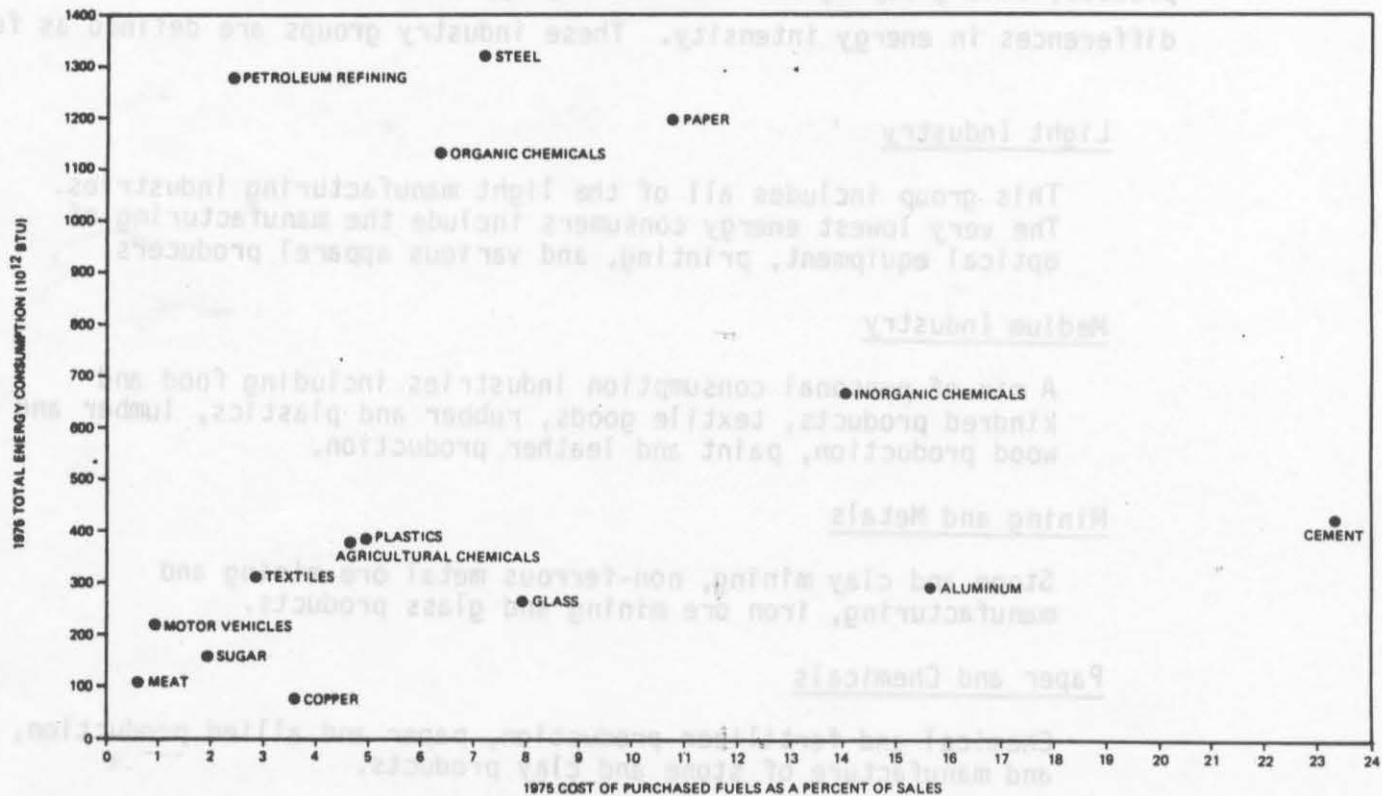
The most accurate method of determining energy consumption by end use for the many subsectors of the commercial/institutional sector is primary data collection. If information is not available from utilities broken down by user and end use, it is common practice to survey actual users. A sampling of commercial/institutional establishments in each subsector will provide a good estimate of locally specific end use requirements. The size of a statistically reliable sampling will depend on the size of the community.

● Industrial

A community's industrial energy consumption depends on the distribution and makeup of its industry population. Steel, petroleum refining, paper and organic chemicals are the highest energy users, as shown in Figure 2-5.

FIGURE 2-5

Total Energy Consumption and Cost Importance in Selected Industries



Source: Department of Energy, Industrial Energy Conservation Strategic Plan, July 1978, p. 1.

Clearly, the first step in the industrial segment of the community energy audit is to complete a census of local industry. The National Census of Manufactures (prepared every five years in years ending in 2 and 7) and the Annual Survey of Manufacturers, include much information broken down by Standard Industrial Classification (SIC), including number of employees, number of establishments, and value added by manufacture. With this last figure, you can compute a preliminary figure for industrial energy consumption by using the energy coefficients provided in Figure 2-6.

The averages provided in the table below offer a useful starting point for evaluation of local energy demands in the industrial sector. Though energy intensity depends on plant characteristics and the specific industrial process, this grouping of five industry types characterize the major differences in energy intensity. These industry groups are defined as follows:

Light Industry

This group includes all of the light manufacturing industries. The very lowest energy consumers include the manufacturing of optical equipment, printing, and various apparel producers.

Medium Industry

A mix of personal consumption industries including food and kindred products, textile goods, rubber and plastics, lumber and wood production, paint and leather production.

Mining and Metals

Stone and clay mining, non-ferrous metal ore mining and manufacturing, iron ore mining and glass products.

Paper and Chemicals

Chemical and fertilizer production, paper and allied production, and manufacture of stone and clay products.

Synthetics

Plastics and synthetic materials production, chemical and chemically-related production, paving mixture, asphalt felts and coatings production. Primary iron is also included in this group.

Source: Department of Energy, Industrial Energy Conservation Strategy, July 1978, p. 1.

FIGURE 2-6

INDUSTRIAL-ENERGY-EMPLOYMENT-LAND USE

by SIC GROUP

SIC	Thousand Btu Per \$ Value Added	Employee Per \$ Million Value Added	Million Btu Per Employee
20 Food & kindred products	286.6	75.7	3545.6
21 Tobacco Manufacturers	46.5	22.4	2075.1
22 Textile goods, floor coverings, yarns & threads	350.5	120.7	2903.4
23 Miscellaneous fabricated textile products	127.4	138.6	919.7
24 Lumber & wood products plus containers	268.5	133.6	2010
25 Household & other furniture & fixtures	94.7	112.6	841.2
26 Paper & allied products plus containers & boxes	966.8	80.9	11957.6
27 Printing & publishing	57.0	101.3	562.5
28, 29 Chemical, plastic, paint, drugs, cleaning & petrol. products	35.4	58.2	608.2
30 Rubber & miscellaneous plastic products	219.0	84.1	2604
31 Leather footwear & in- dustrial products	115.4	163.9	703.9
32 Glass, stone & clay products	1166.5	90.0	12957.2
33 Nonferrous, iron & steel manufactur.	1691.6	73.2	23108.7
34 Fabricated metal products	143.8	89.2	1611.7
35 Engines, Construction & in- dustrial machinery	114.5	86.2	1327.7
36 Electrical equipment, appliances & machinery	92.4	93.7	983.5
37 Transportation vehicles & equipment	105.9	75.9	1395.6
38 Professional, scientific photo. equipment	60.1	85.5	702.6
39 Miscellaneous Manufactur.	76.4	119.8	637.7

Industrial Energy - Employment - Land Use

By Industry Group

<u>Industry Group</u>	<u>Energy Per Dollar Value Added (Thous. Btu/\$)</u>	<u>Employees Per Dollar Value Added (Emp./Mill. \$VA)</u>	<u>Energy per Employee (Million Btu/Emp)</u>	<u>Energy Per Acre (Million Btu/Acre)</u>	<u>Employee Per Acre</u>
Light Industry	10.5	90	120	3360	28
Medium Industry	32	100	310	8680	28
Mining and Metals	72	59	1170	9360	8
Paper and Chemicals	129	62	1710	13680	8
Synthetics	-	46	-	-	16

Source: The Planner's Energy Workbook, T. Owen Carroll, BNL-50633, pp. 34-41.

A warning should be issued here regarding the industrial sector. Land use does not directly affect industrial energy demand.⁶ For many industries, the largest part of energy consumption is devoted to the industrial process itself. In these instances, opportunities for utilizing more efficient technologies to produce process heat may exist (see the technology overviews in Part IV, Resources). In addition, factories and plants may be able to decrease heating and lighting energy used through "housekeeping" measures, such as installing insulation, maintaining HVAC equipment and reducing overlighting. In the long run, the United States may experience a shift to a less energy-intensive product mix, as some European countries already have.

- Transportation

The transportation energy audit is a relatively straightforward exercise. It includes both passenger and goods movement within the community, and is comprised of travel by the following modes:

- Autos
- Trucks
- Buses
- Mass transit (rail or subway)

Most urban areas of 50,000 or greater have continuing comprehensive transportation planning studies from which annual Vehicle Miles Travelled (VMT) should be available. In smaller communities, state and regional agencies should be able to provide this data. Though annual VMT varies substantially between areas of the same population, the following table provides some guidelines against which your local data can be checked:

Community Size (Population)	Annual VMT/Capita
5,000 - 49,000	3,900
50,000 - 99,000	4,400
100,000 - 249,000	4,600

Source: 1974 National Transportation Study, U.S. Department of Transportation, 1972 Data.

In using these numbers it should also be remembered that they are derived from 1972 data, and that transportation patterns in many communities have undergone pendulum swings as gas prices have fluctuated.

Availability of transportation information varies too widely to suggest generic ways of collecting data. But census data is available in this sector, and many agencies have conducted transportation studies. Local trucking companies might also prove a useful source for freight VMT. To determine

energy consumption from VMT, use state or local derived vehicle efficiency ratings often available from transportation departments. Local transit travel figures may be available from the local transit authority.

- Government

Though the government land use category is comprised of the same types of energy users as other categories -- office buildings, auditoriums, cars -- it is often handled as a separate category in an audit because its energy use is directly controlled by a local or regional government. This portion of the audit will not contribute to policy formulation as much as suggest local government conservation opportunities. These savings may represent an important fiscal opportunity as well. Since escalating energy costs are consuming an increasing percentage of municipal budgets, energy savings can help preserve a balanced budget without cutting government services.

The energy consumers in the government sector can be categorized as follows:

- Outdoor lighting
- Schools/colleges
- Waste water treatment
- Water supply
- Solid waste disposal
- Police and fire protection
- Streets and maintenance
- Administration

This breakdown may not be appropriate for the energy profile process in all communities. Ideally, the breakdown should align with existing bureaus or divisions, whose budgets and bills are separate and distinct. It may also be easier to break down consumption by some other categories, as for example: vehicles, water (waste and supply), lighting and buildings. In fact, the allocation does not matter as long as it is in a usable and easily referenced.

Because all municipal fuel bills are available within the confines of the government and its bureaus, the audit process is much less difficult in this sector. Whereas in the other sectors, much of the data collected was second-hand, inferred or estimated, much of the government sector data will be collected first-hand. The first step is to collect utility and gasoline bills from each department, to determine their current energy consumption patterns. This step will result in figures representing their energy use by fuel source.

Upon completion of the community-wide energy audit, the planner is in a position to construct a complete picture of how much of each type of energy is consumed by each sector in the community. The profile provides a foundation for identifying major fuel users and for setting priorities with respect to formulating specific energy-related policies and programs. The profile can also serve as a key selling document for demonstrating to both local officials and the general public the need for energy initiatives. For the planner these initiatives can start with revisions in the master plan elements to incorporate an energy dimension. Techniques for achieving this are the subject of the remaining sections of Part I of this guidebook.

- Administration
- Streets and maintenance
- Police and fire protection
- Solid waste disposal
- Water supply
- Waste water treatment
- Schools/colleges
- Outdoor lighting

This breakdown may not be appropriate for the energy profile process in all communities. Ideally, the breakdown should align with existing bureaus or divisions, whose budgets and bills are separate and distinct. It may also be easier to break down consumption by some other categories, as for example: vehicles, water (waste and supply), lighting and buildings. In fact, the allocation does not matter as long as it is in a usable and easily referenced.

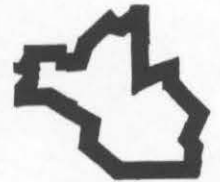
FOOTNOTES

Energy Profile

1. Alan Okagaki and Jim Benson, County Energy Plan Guidebook (CEP), Institute for Ecological Policies, p. 3-4.
2. For a thorough discussion of the soft energy path, see Amory Lovins, Soft Energy Paths: Towards a Durable Peace (Cambridge, MA Ballinger Publishing Co., 1977).
3. CEP, p. 2-1.
4. CEP, p. 7-1.
5. Figures developed by R.W. Mitchell, NESEC.
6. Technology and Economics, An Overview and Critical Evaluation of the Relationships Between Land use and Energy Conservation. Executive Summary. NTIS-PB-258-877, March 1976, p. 7.

Chapter 3

LAND USE



Land Use

Land use policies represent one of the most effective vehicles a community has within its purview for influencing its energy future. Many studies have shown that land use patterns affect energy consumption levels.¹ Different development patterns result in various levels of energy consumption, particularly the transportation sector. Yet changing the development patterns of a community is a long term approach and its effectiveness is closely tied to a community's overall growth rate. In comparison with the effects of individual actions--such as lowering thermostats, insulating homes, buying more fuel-efficient cars, and driving less--are more immediate and more quantifiable. While such measures yield substantial savings they are achievable only through the aggregation of individual decisions. In contrast, changes in land use policies and regulations requires action only on the part of a local government and their effects are longer-term and, ultimately, more far reaching than household decisions. Making energy efficiency a goal of land use policy can guarantee an energy-efficient infrastructure for future decades and yields repeated savings over that time period.

Experts disagree as to the actual energy savings possible through land use controls, though all concur that it is an important tool of energy-efficiency. Conservative estimates from the Urban Institute predict at least 15 percent savings in transportation energy demands from moderate changes in land use policies, and 30 percent savings in space heating and cooling energy in multifamily housing as opposed to single-family detached units.² A more optimistic report, The Costs of Sprawl by the the Real Estate Research Corporation, indicates that high-density communities with energy-efficient land use policies can be expected to use 74 percent, including both space-conditioning and transportation savings, less energy than unplanned sprawling communities.³ Another study which simulated several

development scenarios for the City of Washington, D.C., indicated that a high-density pattern along existing transportation corridors could be expected to use 25 percent less space conditioning energy, and 50 percent less transportation energy than a low-density, noncontiguous pattern. The list of research results shows that the conservation effects of land use controls are difficult to predict exactly, but all suggest that such controls have a substantial effect on energy consumption.

One of the reasons the end-results of energy-efficient land use controls are so variable is that the effectiveness of such controls is dependent, in the final analysis, on people. Even in a compact development, where the grocery store is only a few blocks from home, some people may still choose to drive. However, adoption of a compact, mixed-use development pattern does provide the opportunity for decreasing auto energy consumption. Some may argue that modifying land development patterns will necessitate changes in lifestyle, and limits personal freedom. But, in fact, major conserving effects can be achieved without major lifestyle changes. Minor modifications in layout, design and landscaping of new developments during the site plan review can achieve dramatic energy savings without requiring significant lifestyle changes.

Many other energy-efficient land use policies can have a positive effect on lifestyle quality, and offer social, economic, or environmental fringe benefits. For example, preventing leapfrog or noncontiguous development can help preserve open space and agricultural land. Encouraging infill development in urban areas can promote downtown revitalization. Clustering housing and preserving natural vegetation to create a tempered microclimate can save money for a developer, and provide a buyer with lower cost housing which also is less costly to heat.

On the other hand, there are potential problems associated with high-density living: noise, loss of privacy, and overcrowding. These disadvantages can be eliminated in most cases through sensitive design, quality construction and the use of open space -- but their potential existence suggests that a community adopting energy efficiency as a land use goal must plan carefully for its implementation. Furthermore, no community should plunge into energy-efficient planning by setting theoretical ideals as

goals. Instead, a community should tailor energy-efficiency planning measures to the specific needs and constraints of the individual community. In other words, a planner must bear in mind that energy efficiency is but one goal of community development, and that it must be meshed with the finances, technical skills, economic, social and environmental needs of the community.

Though the list of methods provided below is not comprehensive, it highlights the most common and effective ways to incorporate energy efficiency into the master plan, and suggests implementation strategies:

- Increase existing residential densities, and encourage new residential developments near employment centers and transit lines.
- Permit and promote, the construction of more multifamily and single-family attached housing.
- Allow mixed-use development.
- Discourage noncontiguous or "leapfrog" development.
- Encourage the use of transportation modes other than cars, including walking, biking, and public transit.
- Maximize the energy conservation and energy production potential of the natural environment.

Each of these methods for increasing community energy efficiency has many variations and implementation strategies which are reviewed briefly below, and in greater detail in the following chapters.

Increase densities near employment centers and transit lines

Moderately high density development is the backbone of energy-efficient land use by virtue of its effect on public transit feasibility and utilization. However, for increased density to achieve its full energy saving potential, the land use and transportation elements must be formulated in an integrated fashion.

Some communities, recognizing this relationship between density and transit use, have created transit station development zones which permit high density, multistory buildings in the form of duplexes, townhouses and low-rise

apartments within walking distance of stations.⁴ Somewhat lower densities should be encouraged along local bus routes.

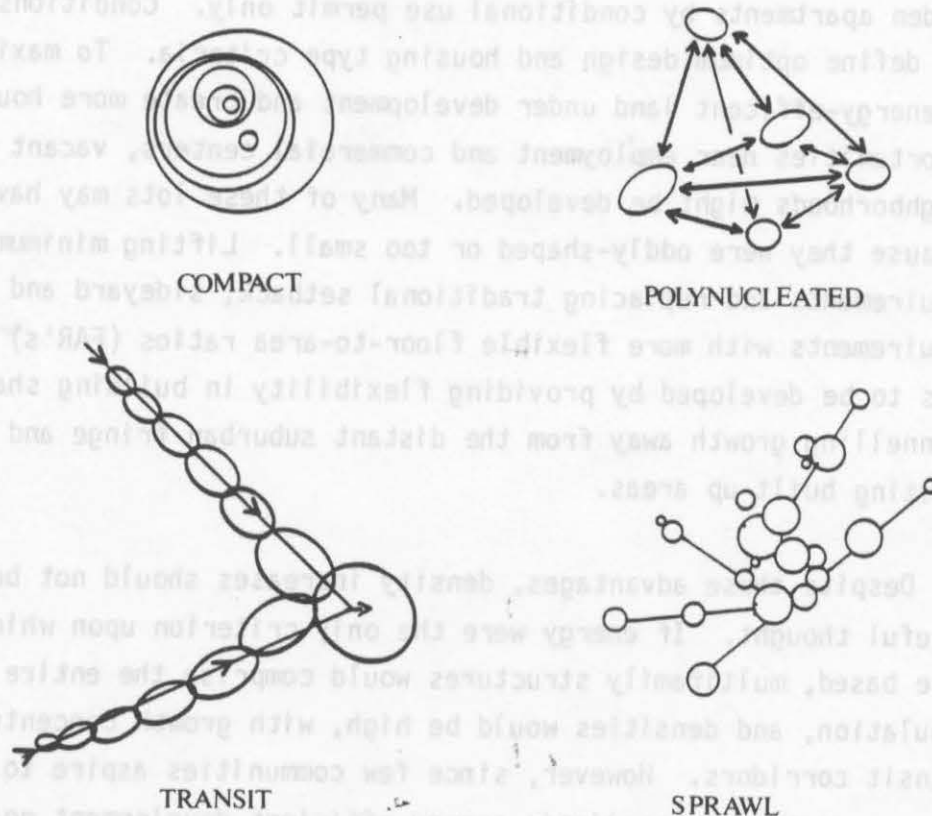
By bringing homes, jobs, and commercial areas closer together, dense development can also reduce trip lengths. A study in Portland, Oregon found that a family residing in the more densely developed urban center uses approximately 65% less transportation energy than a comparable family living in the outlying suburbs.⁵ By rezoning for higher residential densities in single-family neighborhoods or, near the downtown, employment centers and commercial areas, these transportation energy savings can be maximized. To protect existing residential areas from unattractive or inappropriate development, zoning can be modified to allow townhouses, and low-rise or garden apartments by conditional use permit only. Conditions of the permit can define optimum design and housing type criteria. To maximize the amount of energy-efficient land under development and create more housing opportunities near employment and commercial centers, vacant lots in downtown neighborhoods might be developed. Many of these lots may have been ignored because they were oddly-shaped or too small. Lifting minimum lot size requirements and replacing traditional setback, sideyard and height requirements with more flexible floor-to-area ratios (FAR's) can allow these lots to be developed by providing flexibility in building shape and size, thus channelling growth away from the distant suburban fringe and infilling existing built-up areas.

Despite these advantages, density increases should not be promoted without careful thought. If energy were the only criterion upon which developments were based, multifamily structures would comprise the entire housing population, and densities would be high, with growth concentrated along public transit corridors. However, since few communities aspire to this pattern, the more pragmatic and realistic energy-efficient development goals should aim toward creating:

- A compact urban center, with density decreasing in concentric rings
- A polynucleated structure, with high density clusters close to public transit options
- transit-oriented development, with high density residential and commercial development located along transportation corridors radiating from the urban center

These compact development patterns are compared to the energy-inefficient sprawl pattern in Figure 3-1. As illustrated below, sprawl is characterized by low density, noncontiguous residential growth and decentralized growth of employment centers and commerce. Travel patterns are characterized by frequent and lengthy automobile trips, since densities are not sufficient to support most forms of public transit. Single-family detached units, the least energy-efficient dwelling type, are the dominant housing type in the sprawl pattern. Researchers estimate that sprawl patterns are about twice as energy intensive as land use patterns characterized by a dense urban center and the efficient use of public transportation.⁶

FIGURE 3-1



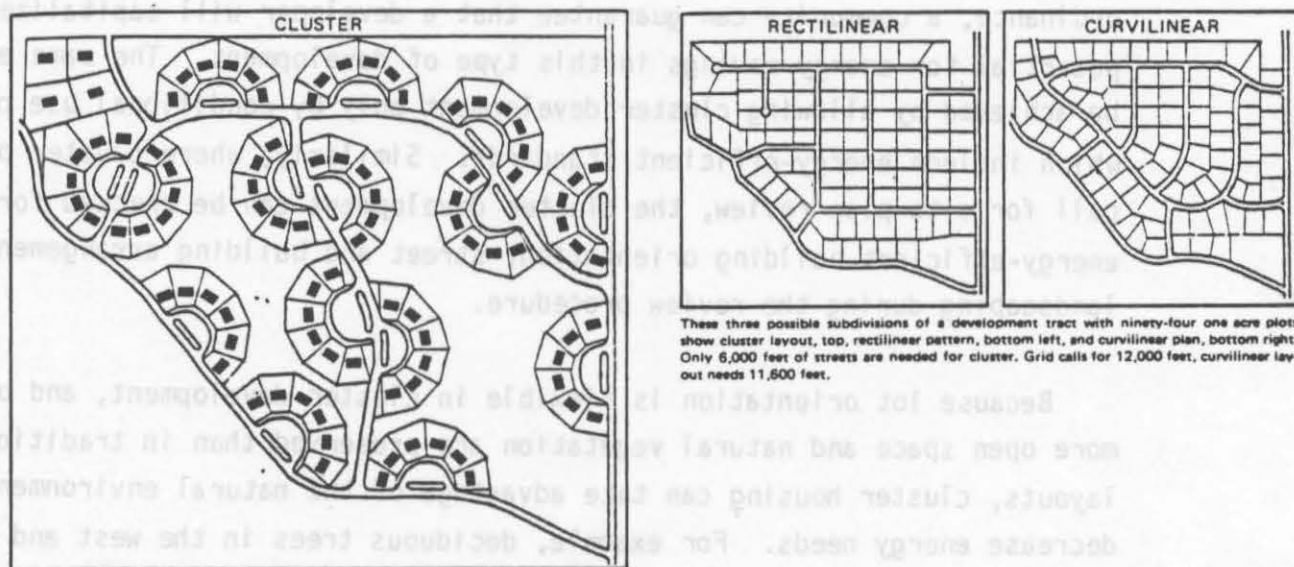
To minimize sprawl, a number of strategies for increasing densities might be implemented. Reducing minimum lot sizes, and floor requirements permits smaller dwelling units to be built. Construction of more compact houses on smaller lots decreases the overall size of the community, thus reducing vehicular travel. Smaller houses also require less space heating and cooling energy.



Cluster housing provides an option in which smaller lot sizes are planned to give a spacious, rather than an overcrowded, feeling. By designating energy conservation as a goal in the 'purposes' clause of the cluster ordinance, a community can guarantee that a developer will capitalize on the potential for energy savings in this type of development. The same effect can be achieved by allowing cluster development only by conditional use permits which include energy-efficient standards. Similarly, where cluster ordinances call for site plan review, the cluster development can be checked for energy-efficient building orientation, street and building arrangement, and landscaping during the review procedure.

Because lot orientation is flexible in cluster development, and because more open space and natural vegetation are preserved than in traditional grid layouts, cluster housing can take advantage of the natural environment to decrease energy needs. For example, deciduous trees in the west and south can be preserved for shading, and trees to the north of a cluster of houses can be preserved to provide a windbreak. Decreasing wind exposure can substantially reduce a house's space heating needs. One study revealed that the heating bill for an unprotected house that is buffeted by a 20 mph wind is more than twice as large as the bill for a similar house under the same temperature conditions which is subjected to only 5 mph wind.⁷ Since a windbreak can reduce wind velocities by 50 percent, windbreaks can clearly have a substantial effect on a cluster's, or an individual house's, heating needs. In addition, by clustering units together, buildings can be arranged to shelter each other from the wind in the winter, while allowing air flow between the structures in the summer. Flexible lot orientations can also allow units to be arranged for optimum access to sun, so heat and hot water can be provided by solar energy. In addition to these space heating and cooling benefits, cluster design reduces energy needed for construction. Since cluster developments, as illustrated in Figure 3-2, have more ungraded open space, and typically also have shorter roads and utility lines, energy consumed to construct infrastructure in a cluster development is less than in a traditional subdivision.

FIGURE 3-2



Source: Harwood, Using Land to Save Energy, Ballinger, p. 78.

Planned Unit Developments (PUD) possess many of the same energy-saving benefits as cluster housing. In fact, in PUD's, lot size requirements, use and density regulations are even more relaxed than in cluster developments, permitting energy-efficient flexible building design and siting, use of the natural environment, and mixtures of building types and uses. Amending the "purposes" section of a PUD ordinance to include energy conservation can guarantee that a development will maximize its energy conservation potential. Higher densities might be offered as a bonus when developers include energy-efficient design and location criteria. Suggested language for such an amendment is provided below:

Density increases: Transportation, siting, layout, landscaping, and design features incorporated in a development shall be considered cause for density increases in the number of dwelling units not to exceed thirty (30) percent, provided these factors make a substantial contribution to the energy conservation objectives of a Planned Unit Development. The degree of energy efficiency and the social and environmental desirability of energy-efficient features shall govern the amount of density increase which the planning commission may approve. Such features may include, but are not limited to, the following:

1. Transportation (a maximum increase of 15 percent):

- a. location close to existing roads, public transportation lines and stations, and activity centers
- b. location contiguous to previously developed land
- c. location close to employment centers
- d. pedestrian and bicycle lanes separate from road systems and connecting residential areas and major activity centers
- e. minimal central road network (width and length), that nevertheless preserves the natural landscape insofar as practicable
- f. facilities for convenient use of public transportation (e.g., transit shelters, restrooms)

2. Siting, layout, and landscaping (a maximum increase of 5 percent):

- a. maximum preservation and use of energy-efficient landscaping, drainage swales, and other natural environmental features
- b. lot and building arrangement and orientation to permit solar, wind, or total energy systems and to shelter buildings from temperature extremes
- c. energy-conserving vegetation planted where most effective
- d. minimized grading of land, both to preserve natural tempering of the environment and to minimize energy expenditures during construction

3. Design (a maximum increase of 10 percent):

- a. buildings arranged in a cluster pattern to follow contour of land
- b. availability within the development of conveniently located public facilities and shopping facilities
- c. mixture of housing types with percent multifamily housing
- d. adequate open space and recreational land for residents
- e. provision of recreational facilities

Though developers appreciate having this kind of guidance up front, energy-efficiency standards can also be applied at the site plan review stage. Again, the objectives of the energy-conservation portion of a site plan review might be: moderately high density, mixed-use development which

reduces residents' need to travel outside the PUD; location close to employment centers which "fit" the skills and income levels of projected residents; cluster housing pattern whose siting and design makes use of topography and vegetation to cut energy needs; and provisions to insure solar access. To guarantee that PUD's are built in energy-efficient locations, a community should assess the transportation energy impacts of the proposed location; its proximity to public transit and to employment opportunities.

Permit construction of more multifamily/single-family attached housing

This objective is a corollary to the previous one. Clearly, constructing higher density dwelling units will increase overall densities. However, by increasing densities through construction of low-rise multifamily and single-family attached units, not only are transportation energy savings realized, but space heating and cooling energy consumption is reduced. Empirical studies have shown that these higher density building types use from 30 to 60 percent less energy than do single-family detached dwellings,⁹ largely because they have less exposed surface area -- i.e., walls and roofs -- through which infiltration and heat loss occur. Higher density development, particularly that created by multifamily housing types, is also more easily adapted to the future use of cogeneration and district heating systems.

To encourage construction of more multifamily/single-family attached units, a community should consider rezoning appropriate areas for these housing types. As suggested under the "Increasing Densities" objective, the most energy-efficient locations for these new zones are near public transit stations, commercial, and employment centers.

A number of other strategies for increasing densities, or eliminating barriers to increased densities, in these "energy-efficient zones" should be mentioned. Conversion of large single-family homes to two-family residences might be allowed. In addition, increasing maximum building height requirements, and floor-to-area ratios (FAR's) allows low-rise multifamily structures, such as townhouses and garden apartments, to be built. Zero lot lines can allow construction of single-family attached residences. As outlined in the discussion of PUD's above, developers might be also induced to include more multifamily structures by providing density bonuses.

Allowed mixed-use development

Mixing uses -- particularly residential, commercial and recreational -- can reduce transportation energy consumption by bringing trip origins and destinations closer together. By increasing mixing of uses near transit stations and bus routes, transportation energy savings can be increased further still, since use of public transit is encouraged, both for visitors and residents. Though incompatible mixed uses which originally inspired segregated zoning should be avoided, commercial, institutional, recreational and residential uses can often be combined with careful rezoning. For example, certain "corner store" and institutional uses -- including churches, libraries, medical offices and neighborhood grocery stores -- might be allowed by conditional use permit. In this way, retail commercial and professional services that contribute to the self-sufficiency of the community might be integrated into a residential zone, thereby decreasing the need for frequent automobile trips. Developments in these zones might be controlled by requiring site plan review, which might also provide an opportunity to incorporate energy-efficient design features. In some instances, conditional use permit systems, which control the location of a use within a zoning district, offer advantages over allowing a mixture of uses as a matter of right. For example, when some uses such as businesses, churches, or recreational centers may create traffic congestion, noise, or mar the appearance of a residential area, it may be preferable to control these uses by the permit system. With conditional use permits, standards may be attached to regulate the size, location, hours of operation, and the appearance of the

newly allowed use. Moreover, the permit system, by controlling location of the use, can further enhance energy conservation by insuring the clustering of uses in an energy-efficient pattern while discouraging strip commercial development.

Mixed uses in zones can be taken one step further -- to multiple use buildings. These mixed-use buildings can, like mixed-use zones, contribute to substantial reductions in transportation energy consumption. Some cities view mixed use buildings as a means to revitalize central cities by keeping activity downtown after business hours. For whatever reasons, if a municipality wishes to encourage mixed use buildings, stringent use restrictions that prevent their construction and operation should be removed. For large multiple use projects -- like Penn Center in Philadelphia, Prudential Center in Boston, and Olympic Tower in New York -- special zoning provisions are required.

In some instances, a mixture of uses can be achieved on a smaller scale through the "accessory use" theory. For example, some types of home occupations might be classifiable as "accessory uses." Since 35-45 percent of automobile trips are for work purposes, decreasing commuting requirements is a worthwhile goal, and one that home occupations can help attain. Ordinances that permit home occupations without requiring special permits might include general performance standards, and a list of permitted and prohibited occupations -- often including such vocations as the legal profession, child care, interior decoration, architecture, and piece work. However, ordinances which do require permits for home occupations do not usually list permitted and prohibited uses, but instead list only performance standards, and rely on a case-by-case evaluation to determine whether a permit will be granted.¹²

Another "mixed-use" rezoning strategy which can save substantial transportation energy for the commuting population mixes housing types rather than uses. Rezoning areas close to employment opportunities, to allow for a wider variety of housing types such as multifamily and smaller single-family attached units, increases the likelihood that people will be able to find homes close to their jobs. Combining this rezoning with a site plan review procedure, can guarantee attractive and appropriate development that

accommodates various income ranges, while also protecting a community from "exclusionary zoning" charges.¹³

Discourage noncontiguous development

Noncontiguous development, or "leapfrogging," is characteristic of the least energy-efficient development pattern -- sprawl -- discussed earlier. Noncontiguous development patterns are not only difficult to service by public transit, require residents to travel longer distances during work, shopping and recreational trips. The alternative to "leapfrogging" is to encourage higher densities within developed areas or, at least, contiguous to their boundaries. By concentrating growth into previously developed areas, not only will transportation consumption be less, but construction costs for streets and utilities, as well as public service costs, is reduced.

Perhaps the most straightforward way for a community to discourage noncontiguous development is by adopting a capital facilities plan that outlines when and where roads, sewer lines, and other public facilities will be extended to energy-efficient locations. (This procedure is discussed in more detail in Chapter 6, Government/Community Facilities.) At the same time, an ordinance that conditions development permits on proof that the project will be served by adequate public facilities should be adopted. In this way, development can be channeled into energy-efficient locations. A community might also try to encourage growth in already developed areas by locating new public facilities near existing activity centers.

Some less established ways of promoting energy-efficient development include open space zoning, land banking and transfer of development rights (TDR). Open space zoning, agricultural zoning and sensitive area zoning might all be used, in certain circumstances, to discourage new development in outlying areas, as well as to protect the land in its current state. Land banking is a little untested land acquisition procedure and it requires substantial financial resources which are rarely within a government's grasp. Theoretically, however, a community could acquire undeveloped land on the urban fringe, and withhold it from development until growth pressures required its release for development in an orderly fashion. TDR can contribute to

energy-efficient growth by allowing owners of land in areas where development is not desirable to transfer (and sell) their "development potential" to land owners in better located, more densely populated districts.

Encouraging the use of transportation modes other than cars

The automobile, even with recent progress to smaller, fuel-efficient models, is still the most energy-intensive mode of transportation. Yet, auto travel represents by far the largest portion of travel in the nation. Though a replacement for the petroleum-powered car lies decades away, substitutes for auto travel exist today in the form of public transit systems, biking, and walking. Land use policies can improve the opportunities for the use of these energy-efficient modes in a community. In fact, many of the strategies outlined above both increase the potential for public transit use and decrease auto travel requirements.

Encouraging higher housing densities -- either through infill development or by allowing multifamily structures -- along major transit streets, near employment opportunities, shopping centers and commercial districts brings the population closer to major travel destinations. In this way, the length of trips will be reduced, possibly allowing more travel by bike or on foot. Furthermore, increased residential densities will make public transit accessible to more of the population, even without the expense of extending routes. Encouraging clustering of commercial uses also increases the viability of public transit. Consolidated commercial development encourages transit use, both because shops are more easily accessible from a central bus stop or transit station, and because parking and traffic congestion serve as disincentives to auto use. However, in some areas, low density commercial development through mixed use zoning can also decrease auto travel demand. Allowing neighborhood stores in residential areas can provide many commercial services within walking or biking distance of home. In addition, allowing some types of offices to be located in homes can provide certain types of services - such as medical, child care and legal - within a neighborhood, and can prevent some commuting energy use.

Biking and walking can be further encouraged in a community by providing bikeways and pedestrian path systems. These paths should be safe, well-lighted, as attractive as possible, and should follow likely routes connecting residential areas to activity centers. If bike paths are to follow existing roadways, it is important that the bicycle lane be marked clearly to exclude autos, and that right-of-way regulations for bikes be adopted simultaneously. Only streets wide enough to accommodate two bike lanes, and at least two auto lanes should be considered for inclusion in a bicycle lane network. In addition, bike storage facilities, both at the origins and destinations of bike lane networks should be improved to accommodate increased bike traffic. The policy statement and route planning for bicycle and pedestrian paths might be included in the circulation plan element of the master plan. Or, it might be incorporated into community land use planning by a separate city ordinance as in the cases of Portland, Oregon and Davis, California the wording of which is reproduced below:

Portland, Oregon--Policy #5: Transportation

Objective #8: To increase bicycle and pedestrian travel in everyday commuting by development of a network of safe, direct routes, provision of secure bicycle storage facilities, and education and promotion efforts.

Davis, California Resolution to Prepare Pedestrian Facilities Plan

- Section I:
- A. The value of walking as an energy conserving, non-polluting form of transportation warrants further consideration of pedestrian planning in existing and future development.
 - B. Pedestrians require certain types of support facilities, walkways signals, benches, bathrooms, and microclimatic factors.
 - C. The Core Area is an ideal location for immediate retrofitting for pedestrians, and would serve as a demonstration for developers and neighborhood groups who wish to improve their pedestrian facilities.

Now, therefore, let it be resolved by the City Council of the City of Davis:

Section II: That the Community Development Department shall prepare...a pedestrian plan for presentation to the City Council...And that this plan shall include recommendations for routing, shading, easement acquisition, and other such facilities as deemed necessary along with a program and budget to develop these facilities in Davis. The Council hereby allots \$10,000 for the preparation and printing of this plan.¹⁵

Communities might also encourage biking and walking by incorporating into subdivision regulations requirements that developers include bike and pedestrian paths connecting residential areas with activity centers in new developments.¹⁶

Further discussion of strategies for encouraging energy-efficient transportation patterns can be found in Chapter 4, Transportation.

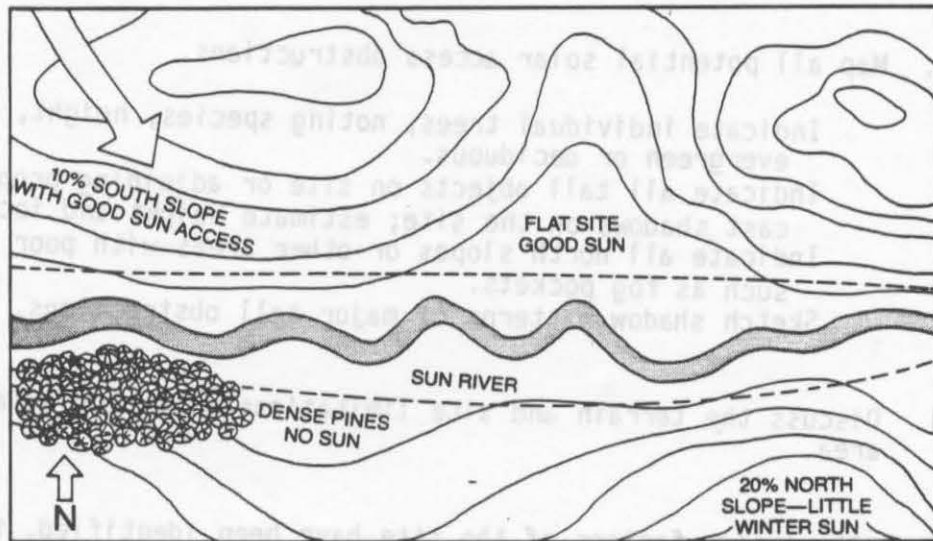
Maximize the energy conservation and energy production potential of the natural environment

The site of a building, whether it is a home, an office, a store or a factory, can substantially affect the structure's energy consumption patterns. The microclimate, or climate of a specific site, is affected by many local site conditions, including winds, ground slope and orientation, topographic features, vegetation, water bodies, and even surrounding buildings. The microclimate can also be tempered through building design, layout and orientation. Though this energy-efficient site planning can decrease the heating and cooling needs of a single building, it will have far greater effects when applied to a complete development or subdivision. It is primarily through these applications that a community can influence energy-efficient building practices.

The first step in planning an energy-efficient development is to analyze the site for energy-conserving and solar access features. These features should be identified and mapped on an aerial photograph, topographic map or

land feature sketch of the site, as shown in Figure 3-3. A possible site analysis checklist to be used in this process is provided below.

FIGURE 3-3



Source: Jaffe and Erley, Site Planning for Solar Access, HUD, p. 43.

Site Analysis Checklist

1. Map topographic and major site features.

- Indicate slopes and flat areas.
- Indicate existing trees and buildings.
- Mark site elevations and contours.
- Mark all significant natural features, such as water courses or historic sites

2. Map all factors that might influence energy consumption at the site.

Indicate seasonal wind directions and features that influence wind flows.

Mark possible frost or fog pockets.

Note bodies of water.

Mark substantial vegetation that might serve as a windbreak or provide shading in summer.

Indicate ground surfaces, such as bare soil, pavement, and grass.

Note reflective surfaces such as sand, water or concrete.

3. Map all potential solar access obstructions.

Indicate individual trees, noting species, height, and whether evergreen or deciduous.

Indicate all tall objects on site or adjoining property that can cast shadows on the site; estimate height and location.

Indicate all north slopes or other areas with poor solar access, such as fog pockets.

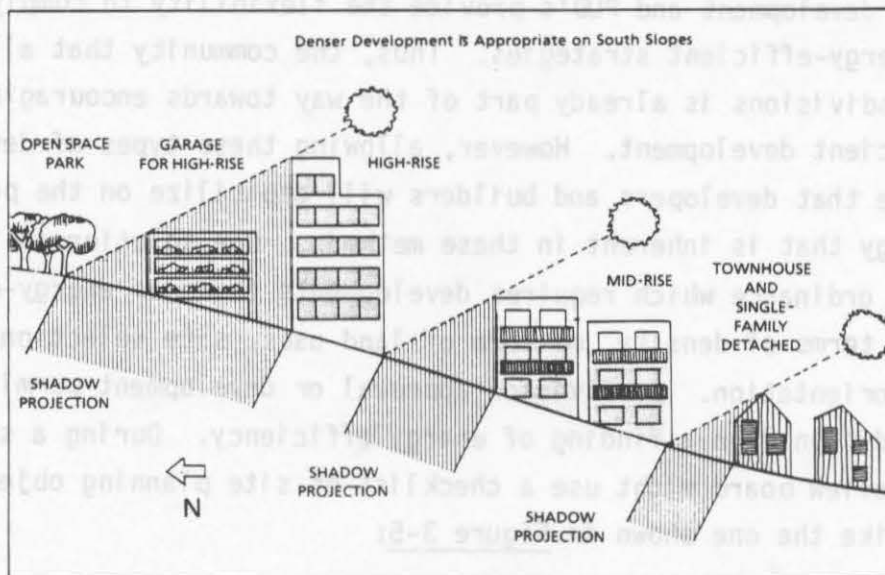
Sketch shadow patterns of major tall obstructions.

4. Discuss the terrain and site limitations with people familiar with the area.

Once the energy factors of the site have been identified, the major land uses -- housing, open space, recreational, transportation, and perhaps, small commercial -- can be allocated. Clearly, areas with poor solar access or with less temperate microclimates should be allocated to open space. Housing is ideally located on south-facing slopes, to provide better solar access and protection from cold northern winds. As shown in Figure 3-4, south slopes can support higher densities without interfering with structures' solar access. Solar access issues are discussed in greater detail in Part II, Solar Access. Existing vegetation and grades should be preserved, if possible, and utilized as windbreaks or for shading.

However, an ordinance requiring energy-efficient standards should have some provisions to allow developers to prove that the standards are inapplicable in a particular case, or that other strategies may provide comparable or more energy savings.¹⁷ Another means of guaranteeing energy-efficient subdivision design is to adopt a point system, in which developments are awarded energy conservation points for such energy efficient features as: proximity to transportation lines, cluster zoning, increased density, percentage of multi-family structures, provision of bikeways, use of

FIGURE 3-4



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 41.

solar design or active solar systems, proper orientation, or use of natural vegetation and topography in creating a temperate microclimate. In this method, a development would not be granted a permit until it accrued a certain number of points. Variances could of course be granted if extenuating circumstances prevented a project from meeting the energy efficiency requirements. This point system could also be used to weed out the less energy-conserving projects, if the number of building permits is limited, or to provide priority processing for energy-efficient developments. Yet another means of encouraging energy-efficient development is to provide density bonuses to developers who include features such as those listed above. A community might implement a density increase through increased floor-to-area ratios, increased building heights, or reduced lot size requirements.

From a solar access standpoint, streets oriented along an east-west axis are ideal, since houses are most often built with their longest axis parallel to the street. In this way, residences with large roof and wall areas facing due south are encouraged, allowing for both passive and active solar installations. Further information on energy-efficient residential building is provided in Chapter 5, Housing.

Cluster development and PUD's provide the flexibility to comply with many of these energy-efficient strategies. Thus, the community that allows these types of subdivisions is already part of the way towards encouraging energy-efficient development. However, allowing these types of development is no guarantee that developers and builders will capitalize on the potential for saving energy that is inherent in these methods. One solution is to adopt a subdivision ordinance which requires developments to be as energy-efficient as possible in terms of density, mixture of land uses, site selection, building layout and orientation. Subdivision approval or development permits could then be conditional on a finding of energy efficiency. During a site plan review, a review board might use a checklist of site planning objectives something like the one shown in Figure 3-5:

FIGURE 3-5

	Employed by developer	Partially employed by developer	Considered, but not employed	Not considered		Employed by developer	Partially employed by developer	Considered, but not employed	Not considered
A. Efficiency of Site Design					5. Maximum pitched roof areas and minimum wall areas on windward side of building				
1. Most efficient road, water and sewer, and electric utility layout					6. Optimal wind protection to three sides of building				
2. Cluster development					7. Use of wind barriers that direct cold winter winds away from buildings and direct cooling summer breezes into it				
3. Use of party walls					8. Use of snow or other devices for wind protection				
4. Centralized heating for development									
5. Alternative energy source for development									
B. Orientation of Development					E. Natural Ventilation				
1. Land is gently sloping and faces southeast to southwest					1. Plants or detached structural elements used for directing air flow for natural ventilation				
2. Building(s) face southeast to southwest					2. Mechanical air conditioning eliminated by using physical devices to manipulate air				
3. Building(s) positioned in most favorable topographic situation allowed by existing land form (midway up slopes is best)									
4. Building(s) in wooded or otherwise sheltered sites rather than open sites									
C. Wind Protection for Developments					F. Shading				
1. Shelterbelts* used or existing					1. Outside shading devices used to shade major window areas from 10 A.M. to 5 P.M. during summer months				
2. Most effective possible shelterbelt					2. Deciduous shade trees used for shading placed in optimal location for summer shade				
3. Most of development within 10-20 times the average height of shelterbelt					3. Vines used on sunny brick, stone, or concrete walls				
4. Shelterbelts serve more than one purpose					4. Grass or other plant materials used against buildings rather than paving				
D. Wind Protection for Individual Buildings									
1. Wind screen** used for each building									
2. Wind screen optimal distance from building (not further than 5x height or closer than 1/2x spread)									
3. Building oriented between 45° and 90° prevailing wind									
4. Nonheated building spaces on windward									

Source: State of Vermont Energy Conservation Guidelines," prepared by the Vermont Public Service Board and the Agency of Environmental Conservation (Montpelier, April 1974).

Conclusion

In summary, the six energy-efficient land use objectives discussed above provide a "shopping list" of energy conservation strategies for local governments. Each community will have to determine which are appropriate in their own unique environment, and which manner of implementation supports other land use goals. In the following chapters, more specific strategies are provided for each of three plan elements: circulation, housing and government/community facilities.

FOOTNOTES

Land Use

1. Technology & Economics, An Overview and Critical Evaluation of the Relationships Between Land Use and Energy Conservation. NTIS-PB-258 877. 1976.
2. Dale Keyes and George Peterson, "Metropolitan Development and Energy Consumption," Land Use Center Working Paper (draft) (Washington, D.C.; The Urban Institute, Sept 1976), pp. 69-89.
3. Real Estate Research Corporation, The Costs of Sprawl, p. 147.
4. As noted in Corbin Crews Harwood, Using Land to Save Energy (Cambridge, MA: Ballinger, 1976) (p. 70), Montgomery County, Maryland has implemented this transit zone strategy.
5. Portland Energy Conservation Choices, Project Overview, Volume 6, p. 12.
6. Keyes and Peterson, "Metropolitan Development," op. cit.
7. Charles Vidich, "Meeting the Energy Crisis: New Considerations for Planning and Zoning in the '80's," Central Naugatuck Valley Regional Planning Agency, October 1979.
8. This language draws heavily from Frank H. So, et al., "Planned Unit Development Ordinances," Planning Advisory Service Report No. 291, (Chicago: American Society of Planning Officials, 1973), p. 27.
9. Portland Energy Conservation Choices, Volume 6, p. 12.
10. Harwood, p. 83.
11. Portland Energy Conservation Choices, Volume 3B.
12. Harwood, p. 82.
13. Harwood, p. 93.
14. Portland Energy Comprehensive Plan Support Document, #7, Bureau of Planning (Portland, Oregon; Sept 1980) p. 83.
15. "Planning for Energy Conservation," Prepared for the City of Davis by Living Systems, Winters, California, 1976.
16. Harwood, p. 98.
17. Harwood, p. 103.

Chapter 4

TRANSPORTATION



Transportation

As gasoline prices continue to rise and supply uncertainties persist, citizens and communities alike are seeking ways to decrease transportation energy demand. Small, fuel-efficient cars and short distance vacations are two manifestations of energy consciousness. During the oil embargo of 1973-74, transit ridership increased for the first time in twenty years, as large numbers of commuters exchanged their cars for buses and trains.¹ Yet, energy used for transportation still represents more than one-fourth of our total energy consumption, both nationally and in the Northeast region. (See Figure 4-1.) While improved automotive mileage ratings and increasing gas prices will continue to constrain transportation fuel requirements, the exercise of certain authority within a community's purview can contribute to energy-efficient transportation:

- Encouraging use of transportation modes more efficient than cars
- Increasing the efficiency of auto trips by improving traffic flow and encouraging higher occupancies
- Decreasing resident's need to make trips, thus reducing the number of trips made
- Reducing the length of necessary trips

To achieve these goals, a local government has two basic tools at its disposal: land use policy and restructuring of the physical transportation system itself.

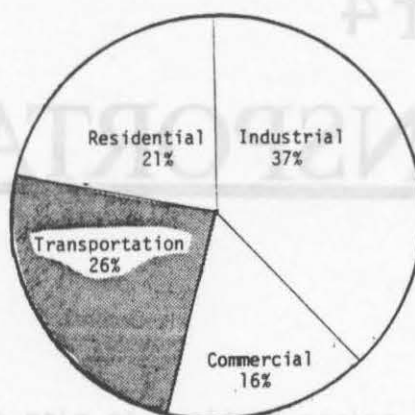


Source: Adapted from "The Potential for Transit as an Energy Saving Option," Federal Energy Administration, Office of Energy Conservation and Environment, March 1976, FEAD-76/254.

FIGURE 4-1

Consumption of Energy by End Use Sector

UNITED STATES

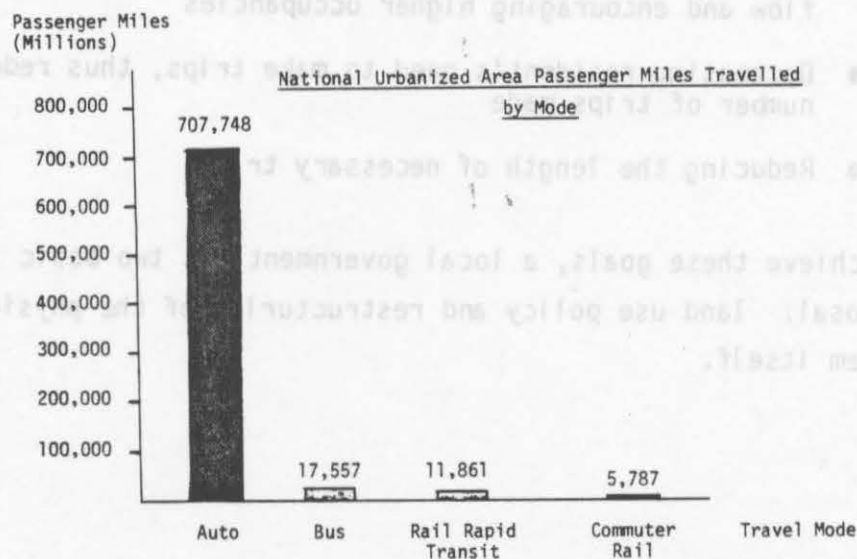


Source: Derived from State Energy Data Report, DOE, April 1980.

Land Use and Transportation

The influence of land use patterns on transportation energy consumption has been examined in many studies.² Transportation energy consumption is shaped by the built environment. Streets, highways and public transit systems determine how one gets from place to place; land use patterns determine the distance between jobs, shopping and homes. Over the last thirty to forty years, cheap, plentiful gasoline and increasing automobile ownership have encouraged the construction of many large thoroughfares and encouraged communities to develop in dispersed patterns which encourage dependence on motor vehicles. Today, automobiles represent by far the largest part of local travel, as illustrated in Figure 4-2.

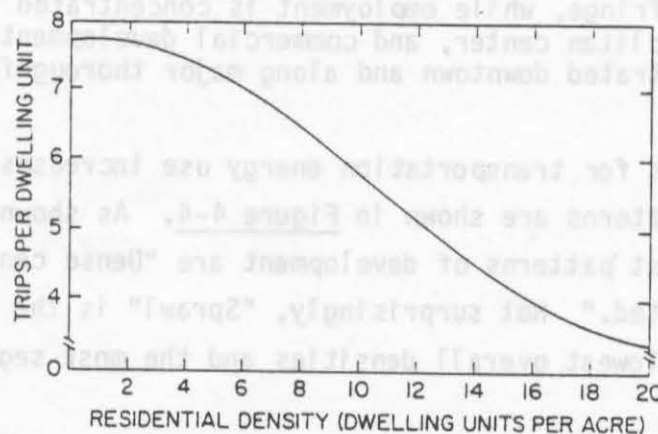
FIGURE 4-2



Source: Adapted from "The Potential for Transit as an Energy Saving Option," Federal Energy Administration, Office of Energy Conservation and Environment, March 1976, FEA/D-76/224.

The number and length of trips taken and the potential for use of modes other than the auto - including public transit, bikes or walking - are impacted by both density and development configurations. Intuition suggests that in areas of high density, auto trips will be shorter and more infrequently made than in areas of low density. This hypothesis has been confirmed by several transportation studies, and is illustrated in Figure 4-3 below.

FIGURE 4-3



Source: T. Owen Carroll, Planner's Energy Workbook, BNL-50633, p. 45.

The spatial distribution of land use activities also plays a dominant role in influencing both the frequency and length of local work and shopping trips. For example, in areas where neighborhood commercial and residential uses are mixed, fewer long-distance shopping trips will be made because many needs can be satisfied at the corner store or the cleaners in the next block.

Several studies have investigated the energy-efficiency of various land use configurations to determine optimum growth policies for communities. It is clear that a compact urban area will require less transportation energy than one comprised of "bedroom communities" 5 to 40 miles from downtown. But these extremes are not typical of most urban areas. Instead, growth policy choices generally fall within one or more of five general land use configurations:

- Wedges and corridors--growth is concentrated along a number of transportation radials, with open space preserved inside the "wedges" created by the "corridors" of development
- Beltway-oriented--all development is located along lands adjacent to a beltway, or highway which encircles the city, originally built to divert traffic from congested downtown streets
- Transit-oriented--high density development of both employment opportunities and housing exists near stops on the public transit system
- Dense center--development is concentrated in the downtown
- Sprawl--residential development exists at low densities on the urban fringe, while employment is concentrated in the metropolitan center, and commercial development is concentrated downtown and along major thoroughfares

Projections for transportation energy use increases for each of these development patterns are shown in Figure 4-4. As shown by the table, the most energy-efficient patterns of development are "Dense center" and "Transit-oriented." Not surprisingly, "Sprawl" is the least energy-efficient, recording the lowest overall densities and the most segregation of different land uses.

FIGURE 4-4

Energy Consumption by Alternative Development Scenarios (in 10^{12} Btu/yr.)

Consumption by Sector	1973 Base	Wedges and Corridors	Beltway-Oriented	Transit-Oriented	Dense Center	Sprawl
Transportation, Automobile	117.9					
Increment		59.5	52.2	33.1	35.1	70.6
Total, forecast year		177.4	170.1	151.0	153.0	188.5

Source: James S. Roberts, Energy, Land Use, and Growth Policy: Implications for Metropolitan Washington (Washington, D.C.: Metropolitan Washington Council of Governments, June 1975).

Obviously, transportation energy-efficiency is not the only criterion which guides land use policy; a community cannot choose to direct growth into a "Dense center" solely because it is most energy efficient. Nor will a community always choose to cluster non-residential floor space in downtowns, even though the higher a downtown's density, and the larger its size, the more travel will shift from auto to transit. However, these results suggest a rule-of-thumb in developing an energy-efficient land use plan. In terms of transportation energy efficiency, the most effective development patterns are those that bring jobs, shopping and the population together.³

Jobs and shopping are the two greatest passenger travel needs. To illustrate, in a survey done in Portland, Oregon in 1975, 45% of the vehicle-miles-travelled (VMT) per day were for work purposes. (See Figure 4-5.) Running a distant second, shopping-related travel represented 18% of total vehicle travel. Though these percentages will of course differ from community to community, the rank order generally remains the same: work trips account for the most VMT, while shopping and errands are the second highest transportation demand factor. It is obvious, then, that bringing these travel needs closer together, either physically or through a transit system, will reduce transportation energy demands.

FIGURE 4-5

1975 DAILY VEHICLE TRAVEL FOR A HOUSEHOLD LIVING IN THE CITY OF PORTLAND

Typical Daily Vehicle Travel Inside the SMSA for a Single Family Household

	Trips per Household per Day*		Length of Trip (miles)	Miles Traveled per Household per Day	
	%	No.		No.	%
Work	34%	2.5	6	15.0	45%
Shopping	21%	1.5	4	6.0	18%
Personal Business	12%	0.9	4	3.6	11%
Doctor—Dentist	2%	0.1	4	0.4	1%
Restaurant	4%	0.3	4	1.2	4%
Social	17%	1.2	4	4.8	14%
Recreational	5%	0.3½	4	1.4	4%
School	5%	0.3½	3	1.1	3%
TOTAL	100%	7.2	—	33.5	100%

*Going to a destination is one trip. Going to a destination and returning is considered two trips. The trips per household per day include all automobile trips by household residents (assuming 1.4 persons per auto trip) plus all bus trips (assuming 1 person per bus trip).

Source: Portland Energy Conservation Choices, HUD, Volume 3B, p. 13.

To achieve the goal of bringing employment opportunities, commercial services and the population together, a land use policy should aim to:

- Locate land uses to reduce distances for each trip, and reduce the number of trips.
- Locate land uses so that more trips can be made by transit, by bike, or on foot, rather than by car.

Though each community operates within different constraints and spatial environments, options which will increase transportation energy efficiency are provided in the "shopping list" below:

- Encourage housing along major transit streets, near employment areas and near shopping centers and commercial districts.

This policy will bring population closer to jobs and shopping, reducing the length of trips needed. In addition, it will facilitate use of public transit, since densities along major transit streets will be increased. Thus public transit will be accessible to more of the population.

- Encourage higher housing density.

High density clustering shortens many trip lengths and discourages auto use because of congestion delays. Residents are also more likely to use transit in higher residential densities, and where neighborhoods are closer to commercial areas.⁴

- Encourage mixed-use zoning.

If residences, jobs and shopping are all found in the same neighborhood, more needs can be satisfied on foot. Allowing only neighborhood commercial business in residential areas prevents changing the character of an area, while still providing many commercial services within walking or biking distance.

- Allow home occupations.

Since work-related trips are the largest percentage of VMT in most communities, home occupations can reduce transportation energy use significantly. Home offices should only be permitted if the outside of the home would not be altered inappropriately, and traffic and parking problems would not be created.

- Encourage/allow home construction on vacant land - including undersized, or oddly-shaped lots - within current community boundaries.

In-town residents use less transportation energy than "fringe" residents, not only because they are generally closer to jobs and shopping, but because they are more likely to use transit.

- Encourage the location of new retail businesses and office buildings in transit-served areas.

Shopping and jobs will be more accessible by transit, perhaps encouraging some auto users to switch to more energy-efficient public transportation. As more stores and offices are built on the transit line, more residents will be likely to use transit, since ridership generally increases with the size of the commercial center.⁵

- Limit the expansion of strip retail development; encourage clustering of commercial uses.

Retail stores which are separated from a commercial center attract auto trips which serve only one purpose, thus increasing the overall number of auto trips. With consolidated commercial development, one stop can serve many purposes, and autos are used less frequently to go from one business to another.

- Add multi-family housing near major employment areas.

Multi-family housing will effectively increase densities, thus allowing more residents to be closer to their jobs, and reducing the length of their work-trips. If residential densities were increased within one-half mile of employment centers, the average length of auto work-trips would be reduced by about one-third.⁶

These options are not appropriate in every community, though they have been successful in some. Overall, in modifying land use policy to increase transportation energy-efficiency, a community should aim for the best match of the locations of jobs, people and shopping.

Transit, Transportation Infrastructure and Energy-Efficiency

Whereas land use policy changes provide some very effective long-term ways to reduce transportation energy consumption, modification, management and/or extension of existing transportation infrastructure present a number of opportunities for increasing energy-efficiency, in the short term. Such measures include:

- Providing more efficient transportation modes
- Promoting, and providing paths for biking and pedestrian use
- Increasing auto efficiency by improving traffic flow
- Increasing the number of passenger-miles-traveled per trip by encouraging increased vehicle occupancies
- Promoting policies which act as disincentives to the single-rider car

Again, not all of these options are appropriate for every community. More importantly, none of them should be implemented without careful assessment of their impacts, and thoughtful tailoring to the specific community's needs.

● More Efficient Transportation Modes

Even with today's improved miles-per-gallon ratings, the car is still one of the most energy-inefficient transport modes. As is shown in Figure 4-6, buses and mass transit use half the energy that a car does per passenger mile. However, it is important to remember that the effective energy cost depends on the extent to which the vehicles (cars, buses or subways) are occupied by passengers. In addition, the two most energy-efficient travel modes--biking and walking--should not be overlooked, particularly since they have lately enjoyed something of a renaissance because of their health benefits.

FIGURE 4-6

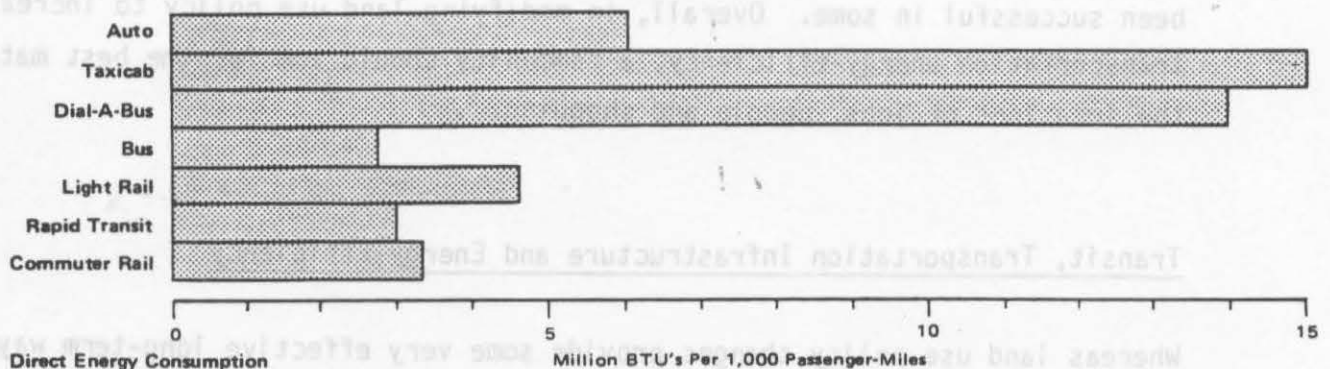


Exhibit assumes the following average occupancies (persons per vehicle):

Auto, 1.5; Taxicab, 0.7; Dial-A-Bus, 1.2; Bus, 11; Light Rail, 10; Rapid Transit, 24; Commuter Rail, 31.

Source: "Where Transit Works: Urban Densities for Public Transportation," Regional Plan News, August 1976, p. 13.

Energy efficiency is not the only consideration in choosing a transportation mode. Many other factors impact on the choice, including: economic feasibility, system size, demand, and the effect of density on ridership. Cost of a transit system varies greatly with the size of the system, the cost of the vehicles and guideways, and the current interest rate. Evaluating costs by itself, however, does not produce very useful results. Passenger demands, which is integrally related to the density of the community's development, should be considered first.

Several variables impact on the determination of a community's development density and what "density of service" it can support, including residential density at the origin, the distance to commercial nodes, the size and density of those commercial destinations, and their character (industrial, office or shopping center). Figures 4-7 and 4-8 provide some general guidelines relating densities of both origins and destinations to travel modes. Research conducted by the Tri-State Regional Planning Commission in New York indicates that the following relationships exist between residential density and transit use:

- At densities between 1 and 7 dwellings per acre, transit use is minimal.
- A density of 7 dwellings per acre appears to be a threshold above which transit usage increases sharply.
- At densities above 60 dwellings per acre, more than half the trips are made by public transportation.

In low density areas and small communities, taxis may represent the only feasible form of public transit. However, they do not significantly reduce energy costs, nor can they be expected to serve a large share of passenger travel because of their high costs to consumers.

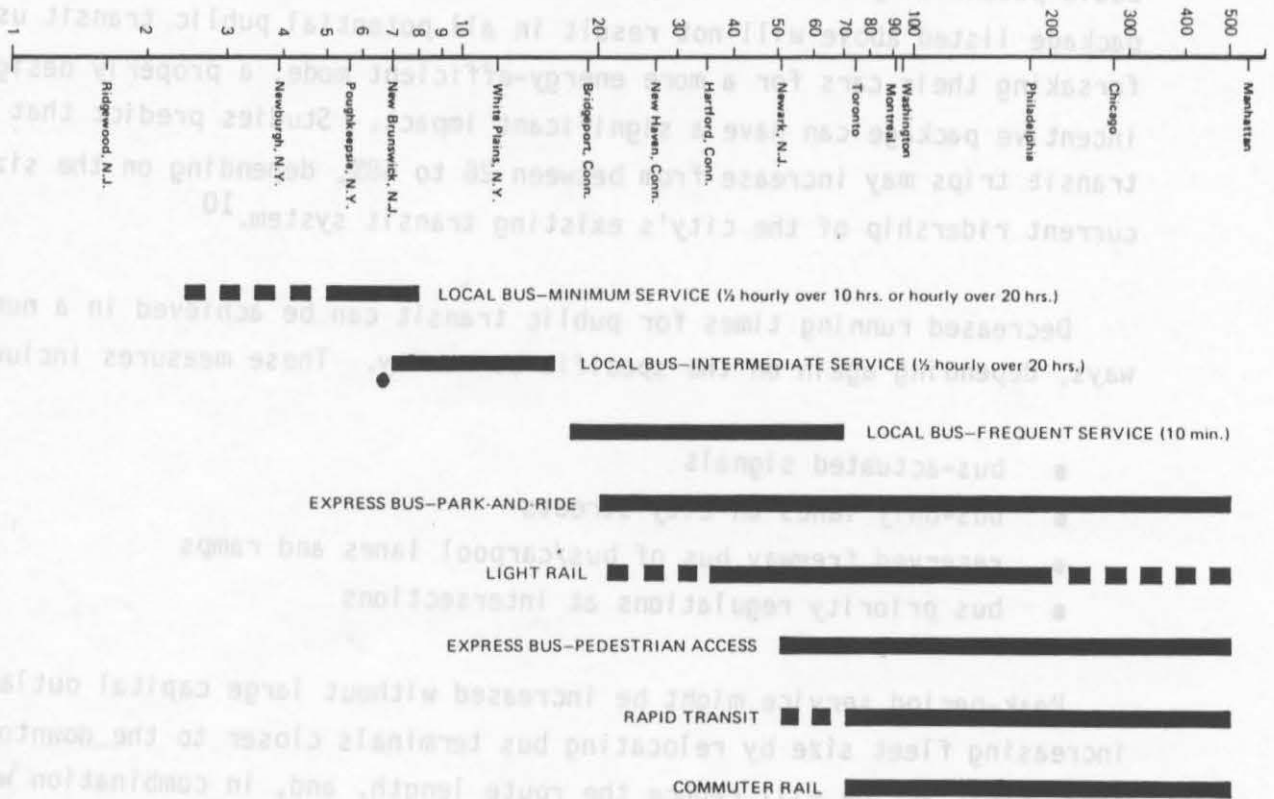
FIGURE 4-7

Transit Modes Related to Residential Density

Mode	Service	Minimum Necessary Residential Density dwelling units per acre	Remarks
Dial-a-bus	Many origins to many destinations	6	Only if labor costs are not more than twice those of taxis
Dial-a-bus	Fixed destination or subscription service	3.5 to 5	Lower figure if labor costs twice those of taxis; higher if thrice those of taxis
Local bus	"Minimum," ½ mile route spacing, 20 buses per day	4	Average, varies as a function of downtown size and distance from residential area to downtown
Local bus	"Intermediate," ½ mile route spacing, 40 buses per day	7	
Local bus	"Frequent," ½ mile route spacing, 120 buses per day	15	
Express bus —reached on foot	Five buses during two hour peak period	15 Average density over two square mile tributary area	From 10 to 15 miles away to largest downtowns only
Express bus —reached by auto	Five to ten buses during two hour peak period	3 Average density over 20 square mile tributary area	From 10 to 20 miles away to downtowns larger than 20 million square feet of non-residential floorspace
Light rail	Five minute headways or better during peak hour.	9 Average density for a corridor of 25 to 100 square miles	To downtowns of 20 to 50 million square feet of nonresidential floorspace
Rapid transit	Five minute headways or better during peak hour.	12 Average density for a corridor of 100 to 150 square miles	To downtowns larger than 50 million square feet of nonresidential floorspace
Commuter rail	Twenty trains a day	1 to 2	Only to largest downtowns, if rail line exists

FIGURE 4-8

Downtown Size, Million Square Feet of Nonresidential Floorspace



Note: Downtown is defined as a contiguous cluster of nonresidential use and is larger than the more narrowly defined Central Business District

In communities which can, or already do, support bus, rail or rapid transit service, some attention should be given to encouraging increased ridership. As auto ownership has increased over the past thirty years, transit ridership has decreased. From 1960 to 1972, the number of transit passengers declined at a compound annual rate of 2.9 percent.⁷ Ridership increased during the oil embargo of 1973-74, but transit still only represents 5-8% of the total trips in urban areas.⁸ However, there are a number of incentives that a community can provide to encourage transit use, including:

- Decreasing running times
- Reduced fares
- Increased service coverage and frequency
- Increased peak-period service
- More comfortable, attractive terminals and vehicles

An estimated 60% of travel to and from Central Business Districts (CBD's) could potentially be carried by buses or mass transit.⁹ While the incentive package listed above will not result in all potential public transit users forsaking their cars for a more energy-efficient mode, a properly designed incentive package can have a significant impact. Studies predict that total transit trips may increase from between 26 to 68%, depending on the size and current ridership of the city's existing transit system.¹⁰

Decreased running times for public transit can be achieved in a number of ways, depending again on the specific community. These measures include:

- bus-actuated signals
- bus-only lanes on city streets
- reserved freeway bus or bus/carpool lanes and ramps
- bus priority regulations at intersections

Peak-period service might be increased without large capital outlays for increasing fleet size by relocating bus terminals closer to the downtown area. This action will reduce the route length, and, in combination with some kind of park-and-ride facility, will effectively increase the number and frequency of bus trips, as well as the transit ridership in any given time period.¹¹ Staggered work hours, though difficult to implement, is also often suggested as a means for reducing traffic congestion and transit crowding at peak periods.

Many of these issues and actions are geared to metropolitan and suburban transit concerns. Not surprisingly, these are the areas most conducive to transit use, because of their relatively large CBD's and higher residential densities. Rural and less densely populated areas are less easily handled by traditional transit systems, but often have need of some kind of public transportation. One option is a subscription service, which is similar to "Dial-a-Bus," often used for elderly or handicapped transit users in urban areas. In areas without enough demand or financing to support a daily subscription system, the deviated route system can be used. One bus can be shared between several communities, and people can sign up for bus service on the day that the bus is in their area. This system is being used with success

in the Southern Tier region in New York State whose population of 200,000 is spread over 2,200 square miles. Another option for small urban areas is to establish a "feeder bus" system to extend services already offered by county, regional or private bus companies.

Two other "transit" options which are possible in urban communities, both large and small, are biking and walking. Of course, the potential for these options is limited by climate, physical ability, and bundle-carrying requirements. Studies have shown that walking or biking can replace a maximum of 15.7% of vehicle miles travelled--comprised of those trips which are less than 5-1/2 miles long.¹² Though complete changeover for short trips cannot be expected, riding and biking have recently been transformed into favorite pastimes. To allow for safe usage of these modes, as well as encouraging further use, footpaths and bicycle paths can be provided along highways, roads and streets. Paths must be well-lighted, physically separate from motor vehicle traffic, and should connect residential areas with activity centers. Within new subdivisions, developers might be required to include bike and pedestrian path networks connecting residential areas to activity centers.

Inducements to walking and biking include:

- bikeway and pedestrian path systems
- improved bike storage facilities
- bike priority regulations at intersections
- pedestrian malls
- pedestrian actuated signals

Convenient and attractive pedestrian and bike paths will obviously attract more usage. One study reports that in new communities with two or more pedestrian paths leading to schools, 49% of the children walk to school, compared with 22% in new communities with no pedestrian paths. In Davis, California, land use planning includes routing, shading, easement acquisition and construction of facilities needed along pedestrian and bike paths. Obviously, pedestrian malls encourage walking, partially by increasing the comfort and safety in which people can wander, and largely by eliminating the option of using a car. In fact, this measure is less of an incentive to use other modes of transit than a disincentive to use the car.

Pedestrian malls, or area restrictions as they are more officially called, must be used carefully in American auto-dependent downtowns. Making carless areas too widespread could restrict travel to such an extent that people no longer frequent downtowns, causing business to move to the suburbs. However, if used carefully, this technique can promote urban revitalization. In Boston, Massachusetts and Washington, D.C., pedestrian zones have successfully stimulated economic development, as well as decreasing auto use. In Portland, Oregon, an eleven-block mall with widened sidewalks and special lanes for buses is credited with stimulating some \$100 million worth of new office and public projects in the downtown area.¹³ Area restriction projects have successfully increased transit ridership and decreased auto traffic to the CBD. In many instances the technique is used extensively in the narrow streets of Europe's downtowns. Over 120 European cities in 14 different countries have sizeable pedestrian precincts in their historic centers.¹⁵

- Increasing the Efficiency of Autos

The alternative means to decreasing transportation energy consumption, besides encouraging people to switch to public transit, is to improve the efficiency of the auto itself. Market forces and the price of gas will take care of decreasing vehicle size and improving engine efficiencies. Local and regional agencies have other options available to them to increase efficiencies. These opportunities can be divided into three categories: improving traffic flow, encouraging increased vehicle occupancies (primarily through carpooling), and parking policy.

It is a well-known fact that cars get higher mileage when driven at a steady moderate speed. Local governments can induce this more efficient driving pattern by improving traffic flow through such measures as:

- Maintaining roads to avoid potholes, crevices and other inconsistent surfaces which require speed changes
- Timing signals and placing stop signs to promote steady speeds
- Sizing roads to accomodate traffic flow

Signalization is a well-documented technique for controlling traffic flow and speed. Other traffic control measures which can reduce idle engine time are "right-turn-on-red" and replacement of stop signs in some intersections with "yield" signs. Sizing roads appropriately can avert potential congestion problems, though roads are more often oversized than undersized. Oversizing can encourage high speeds and high volumes - in some cases, changing quiet residential streets into virtual drag strips. In addition, oversizing roads can waste energy simply in their construction. In 1978, 1.5% of the annual total energy consumption (including sectors other than transportation) was for road construction: in asphalt and road oil.¹⁶ Besides avoiding oversizing of roads, another way to decrease materials costs of road-building is to encourage cluster development. Clustering requires fewer linear feet of streets, while also providing the energy benefits of permitting flexible orientation. Another energy burden which oversized streets impose on a community is increasing summer temperatures by as much as 10⁰, making biking or walking uncomfortable and encouraging overuse of car air conditioners.¹⁷ One study recommends the following sizing rules-of-thumb:

- Collector and sub-collector streets, now built typically at 36', reduced to 26'
- Cul-de-sac streets reduced to 18' width¹⁸

A sample resolution implementing reduced streets widths in new development from Davis, California is shown in Figure 4-9.

Clearly, reduction of street widths is an energy conservation measure that must be implemented with care. Congestion can decrease gas mileage, and even cause economic development repercussions by discouraging potential customers from frequenting a CBD.

FIGURE4-9

**SUGGESTED RESOLUTION ADOPTING NEW STREET STANDARDS FOR
DAVIS, CALIFORNIA**

Whereas, the City Council of the City of Davis recognizes that the energy cost of wide streets is excessive, involving in part the energy cost of construction, the energy cost of converting prime agricultural land to streets, the adverse impact of wide streets on the microclimate, and the even more critical effects of resulting sprawl on energy use in transportation, and

Whereas, the adverse microclimate caused by wide streets discourages pedestrians and bicyclists and further increases energy use for transportation by encouraging people to use automobiles with air conditioners, and

Whereas, wider streets reduced perceived impedance and increase speed and reduce safety, and

Whereas, financial benefits of narrow streets are reflected in maintenance savings at a time when City revenues are decreasing,

Now, therefore, the City Council of the City of Davis decrees that it would be in the public interest to revise street standards to minimize energy use and financial cost and directs the Public Works Department to revise the street standards

Be it further resolved and ordered that these revised standards will take effect sixty days after the resolution is passed.

Source: Reprinted from: Living Systems, "Planning for Energy Conservation, Draft Report," Prepared for the City of Davis, California, pursuant to HUD Project Grant No. B-75-51-06-001 (Winters, California, 1976.)

Increasing private vehicle occupancies is another effective, low-cost means of decreasing energy consumption. Unlike expansion of existing transit systems, or even maintenance of road networks, it requires little capital or no construction investment. Yet, it can dramatically decrease energy use. For example, if one person commutes 10 miles each day in a 10 mpg car 10 passenger miles are traveled per gallon of gasoline. If 3 colleagues join the driver, one gallon of gasoline delivers 40 passenger miles travelled. Effective mpg has quadrupled from 10 to 40. In addition, the 30 gallons of gas those passengers might have used had they driven in separate cars is saved. Unfortunately, the average occupancy for work trips in urban areas is only 1.3--not 4.¹⁹ If car occupancy was increased even to 3 the performance figure for the private car would match the energy efficiency of a conventional bus.²⁰ Only 10 percent of all trips to work use carpools, and about three-quarters of these carpools involve only two passengers.²¹

Carpooling has other beneficial effects too. In addition to saving energy, it reduces congestion at commuter hours, thereby contributing to increased mileage for all cars on the road at that time; reduces the need for parking; and provides a "paratransit" option in areas which are difficult to serve by public transit. Vanpools too have proved very successful in providing an alternative to public transit in less dense areas with longer distances.²² Carpool matching and promotion has been most successful when applied to areas with highly concentrated employment, such as central business districts, industrial parks, or large individual employers.

Carpool programs can be administered either by employers or public agencies. Employer programs have typically had higher rates of success than publicly run programs, stimulating increases in carpools on the order of 2-3%.²³ Employer programs have a number of advantages over the public programs. First, since the destination is the same for all employees - for a given number of people, the number of matches between origin and destination is higher. Second, there is less hesitancy on the part of potential ride-sharers since they are not asked to ride with strangers, but rather coworkers. In fact, the desire to show company "team spirit" is often a positive inducement to participate in a ride-sharing program. Employer-based programs also allow for a wider range of incentives including such fringe benefits as: vehicle lending, shuttle service to parking areas, earlier leaving times, weekly free lunches or even salary bonuses.²⁴ Employers are generally receptive to such programs either for public relations reasons or because of savings in parking costs, though they are generally reluctant to cooperate with government agencies on regional ridesharing efforts. Employers seem to be concerned about possible violations of confidentiality if employee records are shared with government agencies in the process of matching.

Public programs have been most successful so far in medium-sized cities.²⁵ They usually involve distribution of questionnaire forms on which respondents indicate home addresses and workplace, at shopping centers, toll booths, parking lots, and/or public transit boarding locations. (Though soliciting participation from public transit riders may seem like robbing Peter to pay Paul, studies show that if existing transit services are upgraded

simultaneously, ridership losses to carpool programs can be offset by attracting new riders, who perhaps could not be matched with a carpool.²⁶⁾ Participation is encouraged with incentives such as:

- priority lanes on freeways
- reduced or eliminated tolls on bridges, turnpikes
- preferential parking, or reduced parking rates.

Toll reductions and priority lanes are low-cost measures to implement, though the latter requires enforcement to be effective. Preferential traffic control - in other words, providing bus/carpool lanes and ramps - can be more costly, and more effective, if made exclusive with barriers. This, of course, reduces the cost of enforcement. Such exclusive lanes are in operation today in many cities, including San Francisco, Boston, Miami, Los Angeles and Portland. As might be suggested by this array of cities, these exclusive lanes are most applicable in metropolitan areas with peak hour congestion problems. In some areas, "contra-flow" lanes which change direction with the direction of heavy commute traffic have been used successfully. Of course, this strategy requires more financial investment, as well as more maintenance and enforcement on a twice-daily basis. The last incentive listed--preferential parking--introduces a set of measures which merit a section in themselves, which are discussed below.

An example of the impact a successful carpooling program can have is provided by the program developed by the Metropolitan Washington Council of Governments. Over 3 years, this program has attracted about 15,000 travelers to carpooling. The Council estimates the program has removed 5,000 automobiles from local streets, saving 48 million miles per year (on a basis of 20 miles per day for 250 days), or about 4 million gallons of gas. The financial investment by the agency totalled about \$600,000, or about \$40 per carpooler. The money saved to the community in unpurchased fuel was about \$7 million (at 15 cents per mile), which means that each carpooler saved \$600 per year, or a 1500% return on investment. In addition, of course, the program had other environmental benefits, including reduction of air pollutants, reduction of congestion, and reduced parking capacity demand.²⁷⁾

- Parking Policy

Parking policy is often a controversial issue. The role that parking management can play in encouraging energy-efficient transportation may help define currently ambiguous policy. Empirical evidence suggest that the availability and cost of parking are major determinants of how people choose to travel to work.²⁸ In the past, parking capacity has risen steadily to accomodate auto demand.²⁹ As a result, a vicious circle begins: parking capacity increases, keeping prices low, so commuters continue to choose to drive since parking is easy to find and cheap to use. To add to this incentive, current parking policies, in general, encourage single-occupancy commuting. First, 93% of all commuters park free, thanks to employer-provided spaces, employer subsidies, and free parking on the streets.³⁰ In addition, current pricing practices favor the commuter, giving a cheaper rate for parking all day than for short-term parking.

Decreasing the amount of parking available, or increasing the price of parking, can result in a decrease in commuting. For example, in Washington, D.C., a 42% reduction in the number of commuter parking spaces resulted in a 13% reduction in auto commuting.³² However, any decision-making about energy use reductions through parking management should be based on traffic and planning data, including:

- measured traffic volumes
- parking demand and availability
- vehicle-miles travelled
- gas and diesel consumption
- auto occupancy rates
- transit ridership (if any)

With this data in hand, and with care not to decrease commuter parking to the point of preventing continuation of business as usual, a community might consider some of the following options:

- Preferential parking and/or reduced parking rates for high-occupancy vehicles.
- Restriction of long-term street parking, while continuing to provide short-term street parking (This strategy is in use in most metropolitan areas today.)
- Issuance of residential parking permits or high-occupancy permits for certain areas, preventing others from parking in those areas.
- Require builders or developers of shopping centers, rather than providing specified number of off-street parking places, to contribute to or set up a transit system.
- Charge a parking tax for all-day parkers, which would be easier to implement in areas where private parking owners already collect general sales and excise tax.

Obviously parking management will have a greater effect on commute driving in metropolitan areas where a large percent of parking is used for work trips. Generally, as the size of an urban area increases, the percentage of parking devoted to work trips increases. Similarly, the amount of private parking as opposed to street parking increases. Thus, particularly in large urban areas, parking policy can be a useful tool in cutting transportation energy consumption, but it is a tool that must be used with care.

- measured traffic volumes
- parking demand and availability
- vehicle-miles traveled
- gas and diesel consumption
- auto occupancy rates
- transit ridership (if any)

With this data in hand, and with care not to decrease commuter parking to the point of preventing continuation of business as usual, a community might consider some of the following options:

FOOTNOTES

Chapter 4

1. Energy Conservation in Transportation, Department of Transportation, p. 46.
2. "Where Transit Works," "Regional Plan News (Tri-State Regional Planning Commission).
3. "Transportation Planning as if People Mattered," Kenneth Orski in Practicing Planner, March 1979.
4. "Where Transit Works," p. 7.
5. "Where Transit Works," p. 7.
6. Portland Energy Conservation Choices, Volume 3 B, p. 28.
7. "Energy, the Economy and Mass Transit," in Energy Conservation in Transportation, DOT, p. 45.
8. Op. cit., p. 46.
9. Energy Primer, Selected Transportation Topics, Department of Transportation, p. 54.
10. Energy Conservation in Transportation, p. 54.
11. Further information on increasing peak period service can be found in "Providing Increased Capacity During Peak Periods," in Energy Conservation in Transportation, pp. 63-67.
12. "Transportation Energy Conservation Options," by D. Rubin et al., in Energy Primer: Selected Transportation Topics, p. 55.
13. "Transportation Planning as if People Mattered," Kenneth C. Orski, in Practicing Planner, March 1979, p. 23.
14. Energy Conservation in Transportation, p. 17.
15. Ibid., p. 24.
16. Derived from State Energy Data Report, April 1980, Department of Energy.
17. "Planning for Energy Conservation," Draft Report prepared for the City of Davis, California by Living Systems (Winters, CA, June 1976), p. 23.

FOOTNOTES

Chapter 4 (continued)

18. "Residential Streets Objectives, Principles & Design Considerations," Urban Land Institute et al., Washington, D.C., 1974, p. 32.
19. "Some Views on Traffic Management Strategies -- with Emphasis on Parking and Energy Use," C.J. Khisty, in Traffic Quarterly, Vol. 34, No. 10, October 1980, p. 517.
20. "Energy Conservation Potential of Urban Public Transit," M. Stuntz and Eric Hirst.
21. "Carpooling: Problems and Potentials," Norbert Oppenheim, in Traffic Quarterly, Vol. 33, No. 2, April 1979, p. 254.
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23. "Carpooling: Problems and Potentials", Traffic Quarterly p. 256.
24. Alan M. Voorhees & Associates, "Carpool Incentives: Evaluation of Operational Experience," Report to the FEA, Washington, D.C., 1975.
25. Energy Conservation in Transportation, p. 14.
26. Energy Conservation in Transportation, p. 14.
27. "Carpooling: Problems and Potentials," Traffic Quarterly, pp. 261-262.
28. Energy Conservation in Transportation, op. cit., p. 18.
29. "Some Views on Traffic Management -- with Emphasis on Parking and Energy Use," Traffic Quarterly, p. 514.
30. Ibid., p. 519.
31. "No More Free Rides," D. Shoup and D. Pickrell, Viewpoint Planning, APA, April 1980, p. 5.
32. "Energy Conservation through Automobile Parking Management," Durwood J. Zaelke, Environmental Law Institute, Washington, D.C., May 1976.
33. "Parking Principles," Special Report 125 Highway Research Board (Washington, D.C.) 1971, p. 11.

Chapter 5

HOUSING

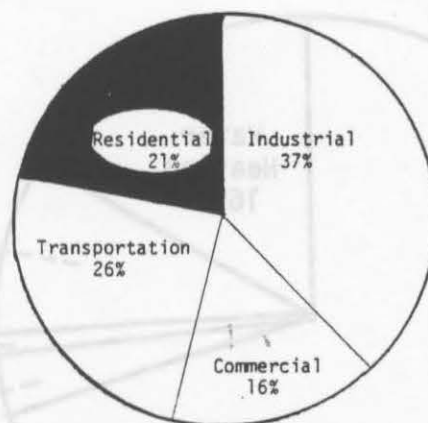


Housing accounts for the largest physical share of the built environment,¹ and represents approximately 20 percent of the nation's total energy consumption. (See Figure 5-1.) Nearly 2 million new homes are built each year, and these dwelling units constitute our housing stock for the next 50 to 100 years. Thus, today's construction is determining our energy consumption patterns for the future. Opportunities to ensure quality energy-efficient building are many, but with each passing day of energy-intensive design, siting, location and construction, chances for decreasing residential energy consumption are missed.

FIGURE 5-1

Consumption of Energy by End Use Sector

UNITED STATES



Source: Derived from State Energy Data Report, DOE, 1979.

Through the energy-efficient land use policies discussed in Chapter 3, Land Use, communities can decrease residential energy costs incurred through housing location. Energy-efficient land use strategies include:

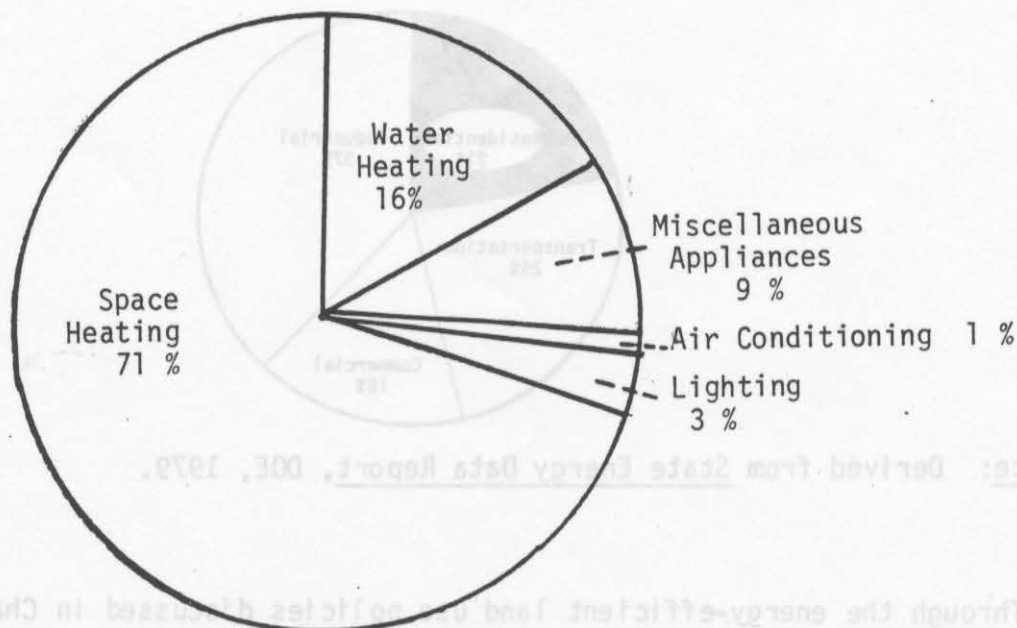
- Encouraging residential construction in previously developed areas
- Encouraging residential construction near employment opportunities and commercial centers, and along transit lines
- Encouraging higher densities
- Increasing mixed-use development

These "locational" policies are primarily aimed at decreasing transportation energy consumption of the residential population. Since automobile travel represents more than 50 percent of the average family's "energy budget,"² these policies clearly have the potential to reduce energy use greatly. However, the 3,500 trillion BTU used by the residential sector each year in the Northeast region - representing about 25% of the region's total demand - is consumed by the buildings themselves -- in space heating and cooling, water heating, lighting and running appliances, as illustrated in Figure 5-2. Here in the Northeast, space heating represents the lion's share of residential energy consumption. Thus, it should be the primary target of conservation efforts.

FIGURE 5-2

Residential Energy End Uses

NORTHEAST REGION



Source: Residential and Commercial Energy Use Patterns 1970-1990, Arthur D. Little, Inc., Project Independence. (1974).

Reduction of space heating energy consumption can be achieved in many ways, some of which are susceptible to local government policies. As illustrated in Table 5-1, large energy savings can be achieved through several simple techniques. But these savings in individual dwelling units translate into energy savings for an entire community only if sizeable numbers of individuals make the decision to conserve energy. Municipal land use and regulatory actions, on the other hand, represent large savings potential with few public decisions which survive the test of political feasibility.

TABLE 5-1

<u>Retrofit Measure</u>	<u>Reductions in Heating Load</u>	<u>Reductions in Cooling Load</u>
Improved ceiling insulation	9%	2%
Insulating glass (or storm windows and doors)	20%	0%
Improved sealing and caulking	11%	8%

Source: Project Independence, Federal Energy Administration, Arthur D. Little, Inc., November 1974, p. 166.

Opportunities for reducing residential building energy consumption through local government action can be broken into four categories:

- Encouraging construction of more efficient housing types, such as single-family attached, cluster and multifamily low-rise
- Encouraging energy-efficient siting of new dwellings and developments, and providing for solar access
- Providing energy conservation guidelines on building materials
- Encouraging energy-efficient and passive solar design of new housing

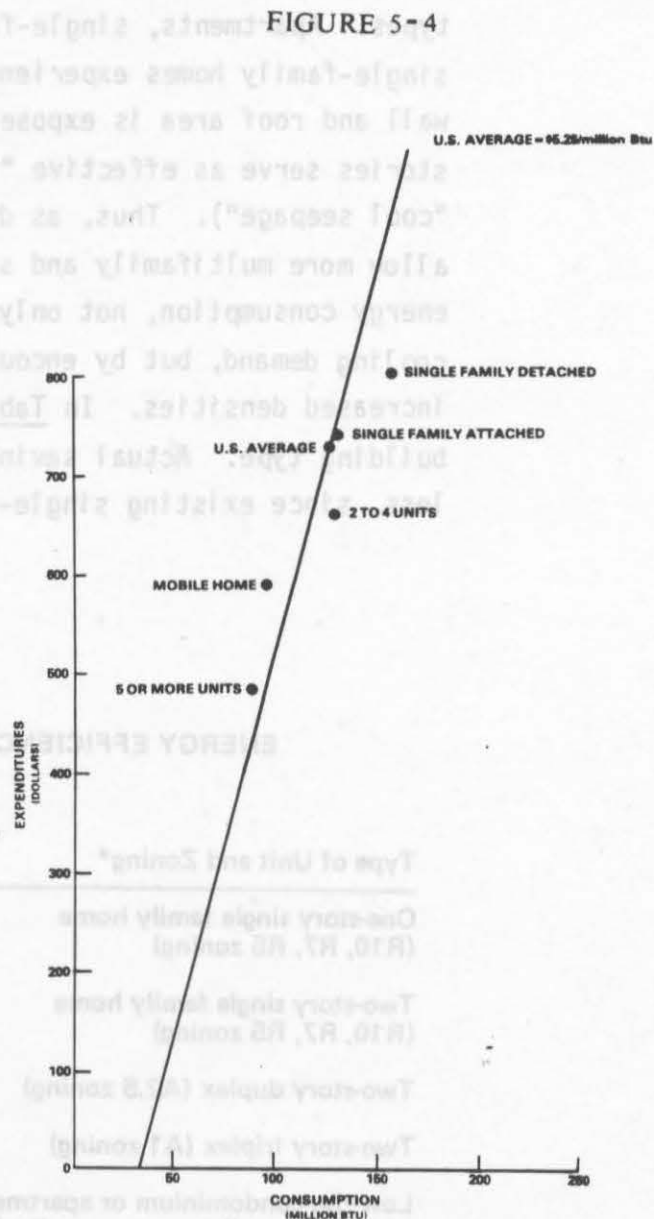
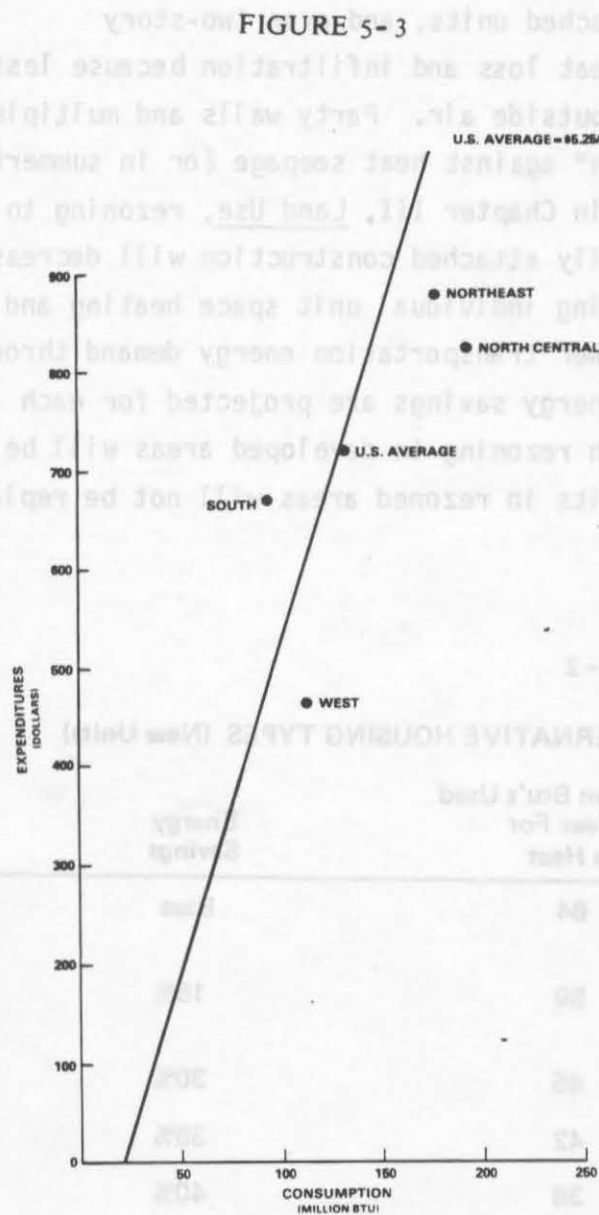
These strategies can be carried out through land use policies, site plan review, subdivision ordinances and zoning regulations. A detailed description of each strategy and possible means of implementation is provided below.

- Encouraging construction of more efficient housing types

Though the energy requirements of a building are of course dependent on the surrounding climate (as illustrated in Figure 5-3), energy demand is also in large part determined by the residential construction type. Residential dwelling types can be disaggregated into four categories:

- single-family detached
- single-family attached (townhouses, row housing)
- multifamily low-rise (2-4 units)
- multifamily high-rise (5 or more units)

(Mobile homes are sometimes considered as a fifth category.) The energy consumption patterns of these four housing types differ substantially, as illustrated in Figure 5-4. Single-family units, both detached and attached, use more energy, partially because they are generally larger than multifamily dwellings. Larger houses require more heating and cooling. In fact, if two houses -- one with 750 square feet of floor area, and the other with 1300 square feet -- are built to otherwise identical specifications, and occupied by two identical families, the smaller house will use approximately 37 percent less energy here in the Northeast.³ By reducing minimum floor area requirements, a municipality can remove barriers to the construction of smaller, and less energy-demanding homes.



Source: Residential Energy Consumption Survey: Consumption and Expenditures April 1978 through March 1979. DOE, July 1980.

But size is not the only factor in the energy-efficiency of single-family attached and multifamily dwellings. Their lower energy requirements are in large part attributable to the lower surface-to-volume ratio of these building types. Apartments, single-family attached units, and even two-story single-family homes experience less heat loss and infiltration because less wall and roof area is exposed to the outside air. Party walls and multiple stories serve as effective "insulation" against heat seepage (or in summertime "cool seepage"). Thus, as discussed in Chapter III, Land Use, rezoning to allow more multifamily and single-family attached construction will decrease energy consumption, not only by reducing individual unit space heating and cooling demand, but by encouraging lower transportation energy demand through increased densities. In Table 5-2, energy savings are projected for each building type. Actual savings through rezoning in developed areas will be less, since existing single-family units in rezoned areas will not be replaced.

TABLE 5-2
ENERGY EFFICIENCY OF ALTERNATIVE HOUSING TYPES (New Units)

Type of Unit and Zoning*	Million Btu's Used Per Year For Space Heat	Energy Savings
One-story single family home (R10, R7, R5 zoning)	64	Base
Two-story single family home (R10, R7, R5 zoning)	59	15%
Two-story duplex (A2.5 zoning)	45	30%
Two-story triplex (A1 zoning)	42	35%
Low-rise condominium or apartment with the same living space as all of the above units (A1 zoning)	38	40%
Typical low-rise apartment with less space than the above units (A1 zoning)	21	67%

* All units are 3-bedroom homes except the last unit, which is a typical small 2-bedroom apartment.

Source: Portland Energy Conservation Choices, Volume 3B, p. 19.

Encouraging construction of more small single-family homes and more multifamily structures is clearly an important part of an energy-efficient municipal program. However, this strategy has socioeconomic fringe benefits also. As financing costs have increased, and inflation has risen, fewer and fewer people can afford to buy a "full-sized" home. In addition the demographic trend towards smaller families and single-person households increases the demand for smaller homes and apartments.

- Encourage energy-efficient siting of new dwellings and developments

After a builder or developer determines the need for a particular building type, or a mix of types, the second determination to be made is the site. In this second decision-making process, there are many opportunities for energy conservation. First, as described in Chapter III, Land Use, the overall location of new development should be near employment and commercial centers, and/or a transit line. Secondly, individual buildings, whether constructed singly or in new developments, can be sited and oriented to take advantage of the surrounding natural features to temper the environment. These natural features, including land forms, vegetation, winds, and the sun, create a microclimate which affects both the heating and cooling requirements of houses, and their potential for solar access.

In the Northeast, heat conservation is the main objective of energy-efficient siting. For this reason, siting should maximize warming from the winter sun and protection from winter winds. Slopes that face slightly east of south provide an ideal environment, with good access to the low winter sun, and protection from winter winds which normally prevail from the north and the northwest. Generally, in this region, buildings should be located on the leeward side of hills, to provide protection from winds. (See Figure 5-5.) Vegetation, especially evergreen trees which maintain their full foliage year-round, can provide further protection from winter winds, if located to the north of a dwelling. Deciduous trees, on the other hand, are ideally located to the south of a building since they allow the sun to warm a house in the cold months, and provide shade in summer, as illustrated in Figure 5-6.

FIGURE 5-5

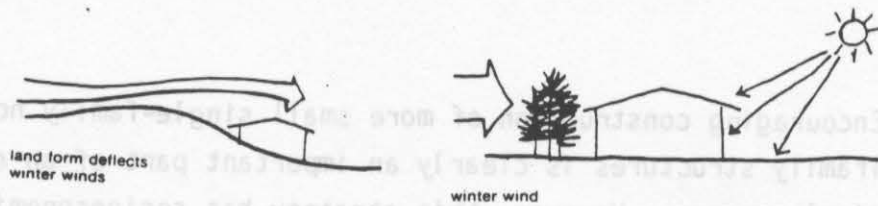
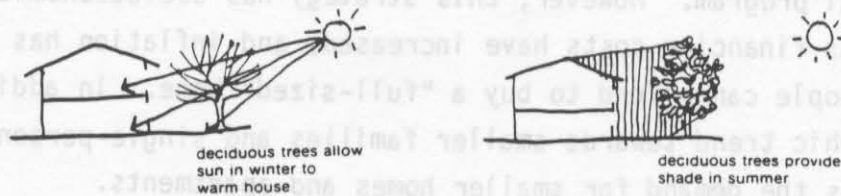


FIGURE 5-6



To maximize the warming effects of the sun, living areas should be placed on the south side of a dwelling, while closets, garages, and utility rooms should be placed on the cooler northern side. In this way, active living areas will take full advantage of the winter sun, and will, to a certain extent, be insulated from winter winds by storage areas.

Applying these simple siting concepts to the orientation of a single building is relatively easy. Applying them to an entire development can be somewhat more difficult and time consuming, but the energy savings will be substantially larger. To facilitate orientation of all houses towards the south, residential streets should be aligned east to west since a home's longest axis is generally parallel to the street. Thus, as illustrated in Figure 5-7, all residences will have a broad southern exposure. If streets cannot be oriented east to west because of topographical or other siting constraints, lots can be oriented with their longest axis running north/south, so that conventionally sited buildings are oriented to the south, as illustrated in Figure 5-8. Street and lot siting to guarantee a southern orientation is covered in greater detail in Part II, Solar Access.

FIGURE 5-7

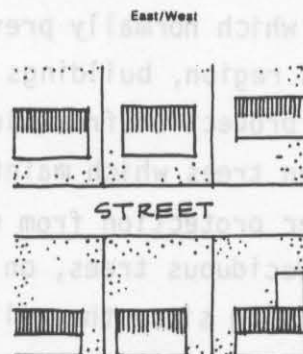
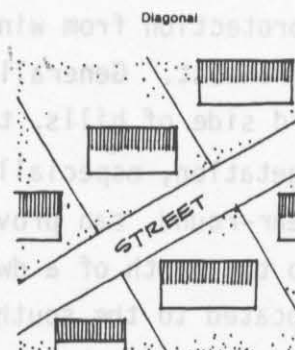


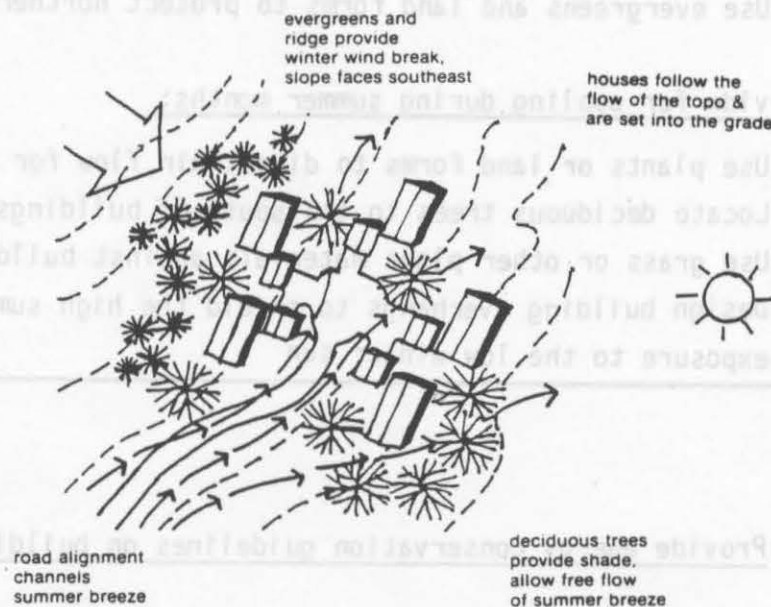
FIGURE 5-8



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, pp. 91-95.

Cluster and Planned Unit Developments (PUD's) are two patterns that are easily integrated with energy-efficient siting. The flexible design standards of cluster housing and PUD's allow preservation of much of the natural environment, and thus, preservation of more temperate microclimates, as illustrated in Figure 5-9. In addition, the increased use of cul-de-sacs, rather than the traditional grid pattern, provides more flexibility in guaranteeing a southern orientation for each home. And residential clustering can help to ensure that the homes shelter each other from winter winds, in effect, creating a mini-heat sink.

FIGURE 5-9



By allowing residential clustering and planned developments, a municipality is clearly increasing the potential for energy-efficient development. However, to guarantee that developers and builders take advantage of that potential, a municipality might incorporate energy conservation standards into the site plan review procedure for new developments. A sample site plan review checklist is provided in Chapter III, Land Use, however, the major objectives and implementation strategies are reviewed below:

Maximize the warming effects of winter sun:

- Utilize south to southeast facing slopes as much as possible
- Create protected sun pockets
- Orient active living areas to the south, and storage space to the north
- Buildings face south to southwest
- Provision for continued solar access included

Reduce the impact of cold winter winds:

- Locate buildings on leeward side of hills in the "wind shadow"
- Use evergreens and land forms to protect northern exposures

Provide for cooling during summer months:

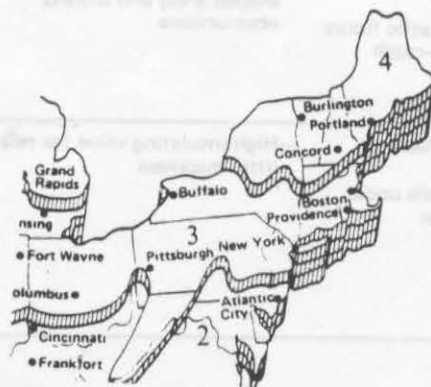
- Use plants or land forms to direct air flow for natural ventilation
- Locate deciduous trees to the south of buildings to provide shade
- Use grass or other plant materials against buildings rather than paving
- Design building overhangs to shield the high summer sun, but retain exposure to the low winter sun

- Provide energy conservation guidelines on building materials

Tempering the natural environment can significantly reduce the heating/cooling strain on a building, but without quality construction and building materials, energy-efficient siting would be in vain. Northeastern homes should be tightly built to withstand cold temperatures and harsh winds. Double or triple glazing should be used on all non-south facing windows, and double-glazing on southern exposures. To reduce heat loss through windows at night, moveable insulation, such as shutters or thermal drapes, might be added. All connections and joints should be caulked and sealed; all windows and doors weatherstripped. Most importantly, a home should be adequately insulated.

Inadequate insulation is the single greatest cause of energy waste in most homes.⁴ Insulation prevents heat loss through the walls, floor, and ceiling, also called the "building envelope." Insulation should be installed in wall cavities, attics, basements, and around plumbing and heating vents. The effectiveness of insulation is measured in "R-values," or their resistance to heat flow. The recommended R-value for wall insulation in this region is between R-13 and R-19. However, the R-value of wall insulation is sometimes limited by the unit's construction. If a wall cavity is only four inches thick, it can only accommodate four inches of insulation, which, depending on the type of insulation used, would have a rating of R-11 to R-13. Today, some houses are being constructed with 2" x 6" studs, 24 inches on center, so that the wall cavity will accommodate six inches of insulation, with a value of R-19. A major problem that can be associated with increasing insulation to this degree is moisture control. To guard against moisture problems, such as decreased insulation effectiveness, mold growth, or structural rotting, vapor barriers should be used with all types of insulation. Many kinds of vapor barriers are available, but they should all be placed so as to face the heated areas of the building. This keeps the moisture in the warm indoor air from reaching the insulation. In Tables 5-3 and 5-4 and Figure 5-10, guidelines for insulation in the Northeast are provided.

FIGURE 5-10



Recommended R-Values

Heating Zone	Attic Floors	Ceilings Over Unheated Crawl Space or Basement
1	R-26	R-11
2	R-26	R-13
3	R-30	R-19
4	R-33	R-22

R-values for various thicknesses of insulation

(in inches)

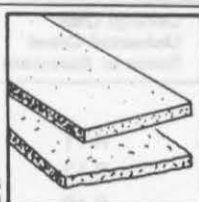
TABLE 5-3

R-Value	Batts or Blankets		Loose and Blown Fill*				
	glass fiber	rock wool	glass fiber	rock wool	cellulose fiber	vermiculite	perlite
R-11	3½ in.	3 in.	5 in.	4 in.	3 in.	5 in.	4 in.
R-13	4	3½	6	4½	3½	6	5
R-19	6	5	8½	6½	5	9	7
R-22	7	6	10	7½	6	10½	8
R-26	8	7	12	9	7	12½	9½
R-30	9½	8	13½	10	8	14	11
R-33	10½	9	15	11	9	15½	12
R-38	12	10½	17	13	10	18	14

*The R-Value for urea-formaldehyde foam is 4.2 per inch of thickness. However, a recent bulletin (Use of Materials Bulletin No. 74, Sept. 15, 1977) from the Department of Housing and Urban Development (HUD) indicates that the effective R-Value of this type of fill is only 3.3 per inch when installed, due to a 6 percent average linear shrinkage. Therefore, urea-formaldehyde foam in a 3½ inch wall cavity would have an R-Value of 10.5.

TABLE 5-4

Types of insulation

Form	Method of Installation	Where Applicable	Advantages	Materials
Blankets or Batts 	Fitted between wood-frame studs, joists, and beams	—All unfinished walls, floors, and ceilings	—Do-it-yourself —Best suited for standard stud and joist spacing, which is relatively free from obstructions —Blankets: Little waste because it's handcut —Batts: More waste, but easier to handle than large rolls	Rock wool Glass fiber
Loose Fill (poured in) 	Poured between attic joists	—Unfinished attic floors and hard-to-reach places —Irregularly shaped areas and around obstructions	—Do-it-yourself —Easy to use for irregularly shaped areas and around obstructions	Rock wool Glass fiber Cellulose fiber Vermiculite Perlite
Blown Fill 	Blown into place by special equipment	—Anywhere that frame is covered on both sides, such as side walls —Unfinished attic floors and hard-to-reach places	—The only insulation that can be used in finished areas —Easy to use for irregularly shaped areas and around obstructions	Rock wool Glass fiber Cellulose fiber Urea-formaldehyde foam (not recommended for unfinished areas)
Rigid Insulation 	Must be covered with ½-inch gypsum board or other finishing material for fire safety.	—Basement masonry walls —Exterior walls under construction	—High insulating value for relatively little thickness	Polystyrene board Polyurethane board Isocyanurate board

Source: Insulation Factsheet, DOE, 1978

To review, other energy conservation items that might be included in a building materials checklist are:

- Double and triple glazing
- Moveable night insulation
- Overhangs or other window-shading devices for summer cooling
- Insulated sub-grade walls
- Insulated slab perimeter
- Insulated doors
- Insulated plumbing runs
- Caulk and weatherstrip penetrations
- Caulk and seal joints and connections
- Continuous vapor barriers
- Seal metal duct joints
- Automatic flue dampers for chimneys
- Water heater insulation package
- Efficient furnace
- Adequate insulation in walls, ceilings and basement

For further information on energy conservation in buildings, and several examples of energy efficient home designs, see the "Passive Solar Design" Overview in Part IV, Resources.

Though building codes are the logical place to include such energy conservation materials standards, a municipality can also provide some guidance in this regard within the site plan review process. Including these energy conservation options within the review process can serve to encourage local builders and developers to improve the energy efficiency of new construction.

o Encourage energy-efficient and passive solar design

The design of a single residence or new development is highly dependent on local residential standards and personal taste. However, energy-efficiency can be incorporated into almost any building design. It should be noted that

the design concepts outlined below will only achieve their full energy conservation potential if building materials and siting have taken energy considerations into account.

As discussed above, a home should be sited so that the living areas face due south and are, therefore, on the sunny, warm side of the home. Baths, garages and storage areas along the north wall serve as buffers against the cold. The location of interior walls and hallways can optimize the flow of air from areas of heat collection to other parts of the home. Small fans strategically placed can ensure a balance of temperature and comfort throughout the house.

Then, by increasing the amount of glazing on the southern exposure, the sun's low winter rays can penetrate and provide warmth to the living space. Additional south-facing glazing can be provided in the form of windows, skylights, or clerestories. As illustrated in Figure 5-11, this additional glazing need not modify the traditional design of the house. One way to provide such additional glass for new construction is to build a solar greenhouse or sunspace on the south side of the house to capture more light and heat. (See Figure 5-12.) The addition of a simple overhang can prevent overheating as the sun moves higher in the sky in summer.

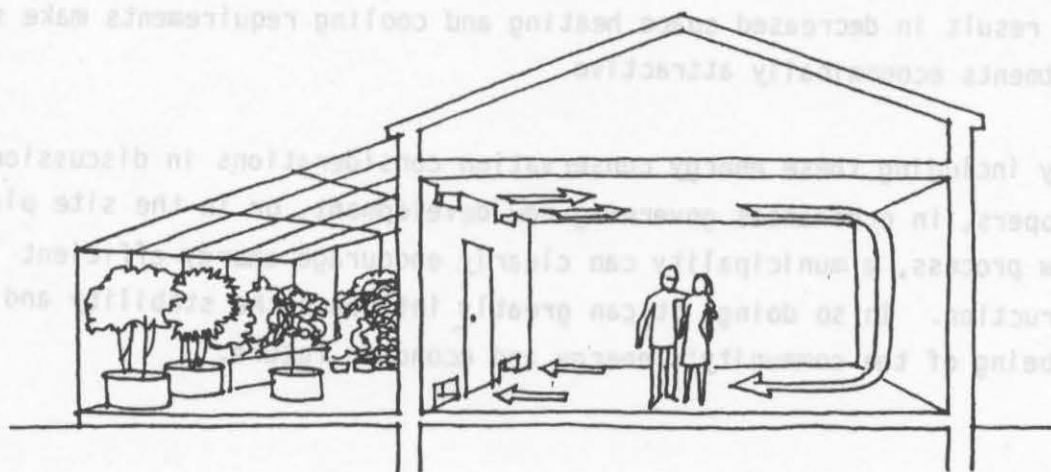
FIGURE 5-11



South Elevation

Source: Northeast Solar Energy Center, Suntempering in the Northeast: A Selection of Builders' Designs.

FIGURE 5-12



Source: Jaffe and Erley, Residential Solar Design Review: A Manual on Community Architectural Controls and Solar Energy Use, HUD/APA.

Finally, the energy-efficient home should incorporate a dense material, or "thermal mass," which can absorb heat from the sun during the day and reradiate this heat to the air when the temperature in the space cools down at night. Water, concrete, brick, slate, tile and sheetrock are all good examples of thermal mass. This mass should be located so it gets full sun for most of the day, and can be in the form of a central chimney, a floor or a wall.⁵ Further information on these passive design principles can be found in the "Passive Solar Design" Overview in Part IV, Resources.

Conclusion

By incorporating energy considerations into the choice of building type, siting, construction and design of housing, residential energy consumption can be cut dramatically. While the costs of incorporating these features are determined largely by the design and materials selected, much new construction can be effectively "sun-tempered" without adding to construction costs at all. Even for those homes whose initial costs are increased by

energy-efficient construction, pay back periods for the incremental expense which result in decreased space heating and cooling requirements make such investments economically attractive.

By including these energy conservation considerations in discussions with developers, in ordinances governing new development, or in the site plan review process, a municipality can clearly encourage energy-efficient construction. In so doing, it can greatly influence the stability and well-being of the community's energy and economic future.

Source: Jaffe and Bray, Residential Solar Design Review: A Manual on Community Architectural Controls and Solar Energy Use, HUD/RAA.

Finally, the energy-efficient home should incorporate a dense-mass, or "thermal mass," which can absorb heat from the sun during the day and radiate this heat to the air when the temperature in the space cools down at night. Water, concrete, brick, stone, tile and sheetrock are all good examples of thermal mass. This mass should be located so it gets full sun for most of the day, and can be in the form of a central chimney, a floor or a wall. Further information on these passive design principles can be found in the "Passive Solar Design" Overview in Part IV, Resources.

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FOOTNOTES

Housing

1. A. Catanese and J. Snyder, Introduction to Urban Planning, McGraw-Hill, p. 281.
2. Portland Energy Conservation Choices, Volume 3A, p. 9.
3. C. Vidich, Least Cost Housing, Central Naugatuck Valley Regional Planning Agency, p. 12.
4. "Insulation Fact Sheet," Department of Energy, DOE/CS-0017, 1978.
5. Northeast Solar Energy Center, "Five Traditional Energy-Efficient Home Designs," which is included in Part IV, Resources.

Chapter 6

GOVERNMENT/ COMMUNITY FACILITIES



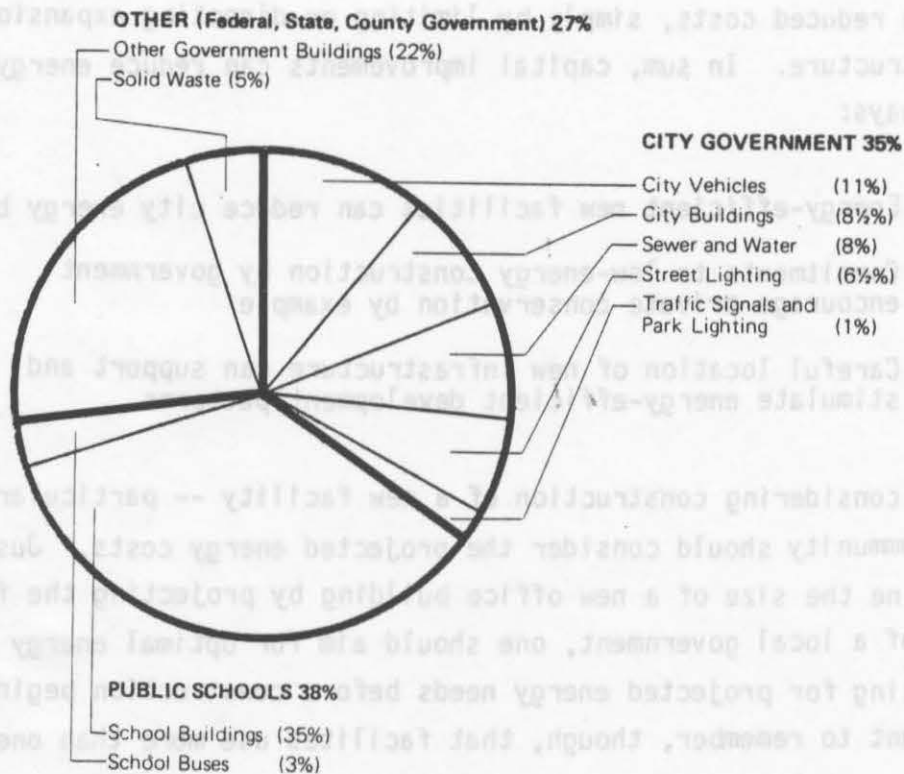
Government

Government typically represents only 1-5% of a community's energy consumption, depending on the size of the community, the number of schools, and what kind of services are provided by the public sector. Though the sector's energy usage is comparatively low, and government facilities are comprised of the same types of buildings as other land use categories, it merits separate analysis because of its direct control by the local or county government. In addition, energy efficiency is often a primary concern of governments because it is consuming an increasing percentage of the municipal and county budgets. Between 1972 and 1976, the price of fuels consumed by municipal governments rose approximately 24% in real dollars.¹ In a nationwide survey of cities and counties in late 1978, government representatives indicated that increasing energy cost associated with delivering public services were a major budget problem.² In addition, energy conservation is a particularly attractive prospect for budget-cutting, since it, unlike most financial cutbacks, does not require unpopular reductions in services offered to citizens. In fact, it may even allow for increases in other services as it reduces government expenditures for energy. Government efforts to spearhead conservation efforts in their communities will also be much more credible and effective if it "practices what it preaches" -- reducing its own energy consumption as it asks its citizens to do the same.

Municipal energy use is dependent on a number of variables, including size, economic and administrative activities. A small community is likely to operate few government buildings and a standard size fleet of police and fire vehicles and school buses. A larger community will have more city government

buildings, public schools, libraries, and -- if it serves as a county seat or regional center -- it also will contain non-municipal buildings. Figure 6-1 provides an example of a city government's energy consumption breakdown (for Portland, Oregon -- an urban community which is also a regional and state commercial center). In this example, the amount of energy consumed by "other government buildings" -- 22% of the city's total energy use -- is much higher than it would be in most communities. Otherwise, the example provides a good "rule-of-thumb" breakdown. Before a city or county addresses conservation opportunities, however, a specific local breakdown of government energy use should be completed. Procedures for completing a profile of government sector energy consumption are provided in Chapter 2, Energy Profile. Researching energy consumption in this sector is often, though not always, less time-consuming than in the private sectors because energy data (including utility bills and gasoline purchase records) can be found in-house. Conservation opportunities in municipal or county government operation exist in the construction of energy-efficient capital improvements and through energy management and maintenance.

FIGURE 6 - 1



Conservation through Capital Improvements

The construction of new facilities provides an ideal opportunity to ensure energy-efficiency over the life of a building, street lighting system or waste treatment plant. Conservation measures which are considered too expensive to retrofit onto existing buildings may be cost-effective in new construction. As these new energy-efficient government facilities replace the existing stock, the municipality's energy budget will be reduced. However, this process will be gradual, given the slow turnover of building stock, and budget constraints which may restrict new construction. In a nationwide survey of local and county governments, 50% of the jurisdictions have policies requiring energy conservation measures in new buildings they construct.³ Because of the high visibility of new construction, government commitments to energy-efficiency and/or renewable energy sources in new facilities have the additional value of encouraging private sector conservation by example. In addition, careful siting of new public buildings and carefully planned expansion of sewer and water lines can encourage energy-efficient development patterns. By planning construction of infrastructure -- sewer and water lines, streets and highways -- a city can influence where new development will occur. Energy-efficient development patterns can be encouraged, at no cost, or even reduced costs, simply by limiting or directing expansion of this infrastructure. In sum, capital improvements can reduce energy consumption in three ways:

- Energy-efficient new facilities can reduce city energy budget
- Commitments to low-energy construction by government encourage private conservation by example
- Careful location of new infrastructure can support and stimulate energy-efficient development patterns

In considering construction of a new facility -- particularly a building -- a community should consider the projected energy costs. Just as one might determine the size of a new office building by projecting the future office needs of a local government, one should aim for optimal energy efficiency by accounting for projected energy needs before construction begins. It is important to remember, though, that facilities use more than one kind of energy:

- Embodied energy -- energy used in construction or manufacture
- Induced energy -- energy use induced by public expenditure
- Operating energy -- energy use for space and water heating, air conditioning, lighting, etc.

Embodied Energy

Energy which is used to construct, manufacture and install a capital improvement is call embodied, or sometimes bound, energy. For example, a certain amount of energy is "embodied" in a steel girder as it is manufactured and put in place in a building. Over 15% of all the energy consumed annually by manufacturing in the U.S. goes into structural materials for building⁴, and therefore represents embodied energy. Embodied energy is difficult to trace, involving many phases of manufacture, transport and construction, and is therefore generally not worth including in the accounting of energy costs of a new facility. However, the cost of embodied energy does raise the issue of building preservation. Many communities and developers have converted old schools into town halls, factories into office buildings, and even warehouses into shopping malls. This practice does save energy in its embodied form.⁵ In addition, older buildings, designed in an era when energy was far less available, often require less energy to heat and cool, particularly if they are "weatherized" during reconstruction. More importantly, however, conversion of older buildings can preserve a community's architectural heritage.

Induced Energy

Energy use which is encouraged or allowed by a capital improvement in induced energy. Since all new development is dependent on city services, capital improvements have a significant impact on future land use patterns and subsequent energy use. Extending a road or a sewer line into previously undeveloped areas invites new development to spring up alongside.⁶ "Leapfrogging" can be discouraged by growth-managed capital facilities programming. Ideally, capital facilities which provide services, such as roads and water lines, should not be extended into fringe areas until all land within the current urban boundaries has been developed. Moreover, other

public facilities, such as recreation areas, libraries and schools, will induce less travel on the part of their users if they are clustered together and near an already developed commercial center or a transit line.

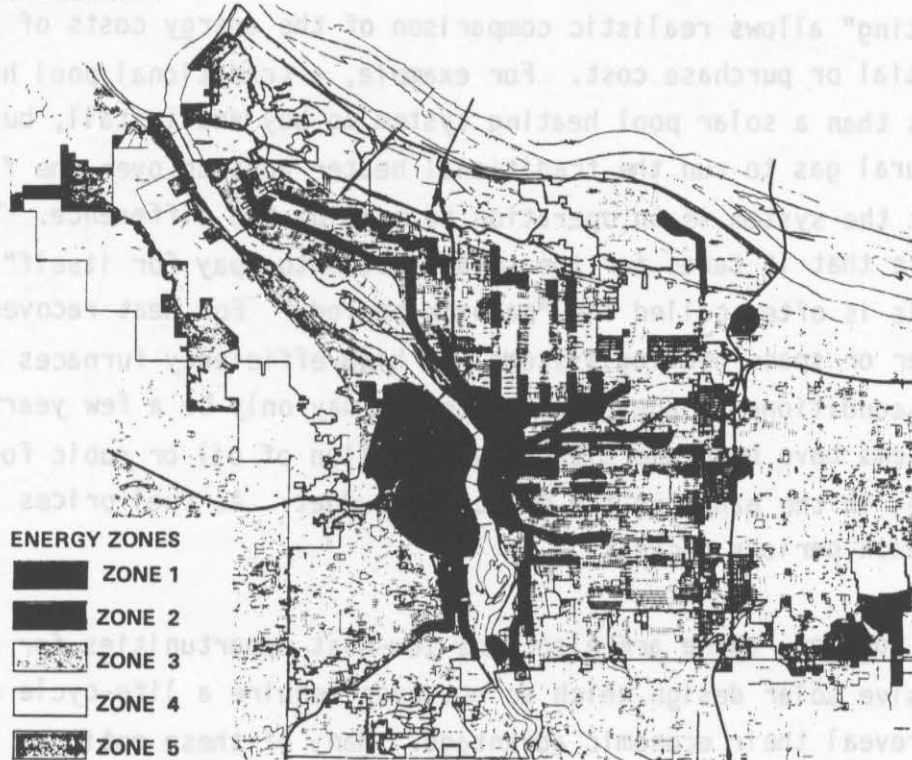
To prevent inefficient siting of new facilities, a planner should evaluate the proposed project site in terms of accessibility and future development patterns. In Portland, Oregon, during the comprehensive energy planning process, the city was divided into "energy zones." (See Figure 5-2.) The energy efficiency ranking of an area is determined by the number of services--transit, commercial and employment--it provides. This energy zone concept can be used as a tool in determining the "energy rating" of a capital improvements project. In other words, capital improvements (and, in fact, new developments of any kind) which are located in "fair" to "excellent" energy zones rate high "energy grades" because they support and encourage energy-efficient development. This methodology does not imply that absolute decisions about the siting of community facilities can be made on the basis of this "energy zone" formulae; there are, of course, many other factors which impact on facilities location. However, a municipality should recognize that capital facilities are powerful land management tools, and that they can be used to shape growth towards energy conservation ends, as well as others.

Operating Energy

The energy used to heat, cool, light and run equipment comprises the category of operating energy. The quantity of operating energy to be used by a municipality is decided by the construction of infrastructure. For example, if 200 street lights are installed on a city street, the energy needed to keep those lights burning for the next 20-30 years is immediately incorporated into the future energy consumption of the city. If a new school is built, the energy to heat and cool the classrooms, light the school and, perhaps, heat the swimming pool, becomes an inescapable portion of the city's future energy budget. Because of this fact, conservation before construction can save dollars for a government budget. To return to the example above, if two hundred 400-watt sodium vapor lights were installed rather than the traditional 1000-watt mercury vapor fixtures, the cost of operating those lights would be approximately 20% lower, yet the lighting levels would be over 15% higher.⁷

FIGURE 6-2

ENERGY ZONES MAP



ENERGY ZONES

-  ZONE 1
-  ZONE 2
-  ZONE 3
-  ZONE 4
-  ZONE 5

ENERGY ZONE

EFFICIENCY RANKING

ZONE 1
Areas served by transit, shopping and jobs.

Sewered areas in Portland that are:
EITHER
Within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations AND within 1/3 mile of major shopping centers AND within 1/2 mile of industrially or commercially zoned land.
OR
Within 1 mile of the central business district.

Excellent

ZONE 2
Areas served by transit and shopping, or transit and jobs.

Sewered areas in Portland that are:
EITHER
Within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations AND within 1/3 mile of major shopping centers.
OR
Within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations AND within 1/2 mile of industrially or commercially zoned land.

Good

ZONE 3
Areas served by transit, or shopping, or jobs.

Sewered areas in Portland that are:
EITHER
Within 1/8 mile of 1995 transit routes or 1/3 mile of 1995 transit stations.
OR
Within 1/3 mile of major shopping centers.
OR
Within 1/2 mile of industrially or commercially zoned land.

Fair

ZONE 4
Other sewered areas in Portland.

Other sewered areas in the City of Portland that are not in zones 1, 2, or 3.

Poor

ZONE 5
Unsewered areas & areas outside city boundaries.

Unsewered areas in Portland and all areas outside present City boundaries.

Very Poor

FIGURE 4-2

Before a piece of equipment is purchased, or a building is constructed, the long-term energy costs should be projected. This practice of "life-cycle costing" allows realistic comparison of the energy costs of a product with the initial or purchase cost. For example, a traditional pool heater may cost less than a solar pool heating system to buy and install, but the cost of the natural gas to run the traditional heater adds up over the first few years that the system is in operation to make up the difference. The number of years that it takes for the solar system to "pay for itself" in reduced gas bills is often called the "payback period." For heat recovery systems, solar water or space heating systems, or high-efficiency furnaces or air-conditioners, the payback periods may only be a few years. Once these systems have been amortized, every gallon of oil or cubic foot of gas saved is money in the bank for the municipal budget. As fuel prices increase, these payback periods decrease.

However, there are also many low-cost opportunities for conservation or passive solar design which do not even require a life-cycle costing approach to reveal their economic advantage. Many of these options, though prohibitively expensive or even impossible to retrofit onto a building or into a piece of equipment, are inexpensive if incorporated during construction. For example, providing for daylighting in municipal office buildings, through use of clerestories or skylights, can substantially reduce energy demand, since lighting represents over 20 percent of the total energy demand in the average office building.⁸ In facilities with large water heating needs, such as schools, laboratories, or public swimming pools, solar water heating systems can cut fossil fuel use dramatically. If sited to take advantage of a temperate microclimate and solar gain, a municipal building can use significantly less space heating energy. Most of the siting and design considerations described in Chapter 5, Housing, can be applied to municipal buildings with similarly dramatic reductions in energy use. (See Chapter 5 and the Passive Solar Design Overview in Part IV, Resources, for more information on energy-efficient siting and design of buildings.)

Energy management and maintenance

The opportunity to reduce energy consumption during construction of new municipal facilities comes infrequently, but conservation principles can also be applied in the day-to-day operations of a local government. Many municipalities across the nation have initiated programs to reduce their own energy consumption, out of a need to reduce their own escalating energy bills. Though these management and maintenance programs are often not glamorous, they can achieve dramatic results. These program options fall into four categories:

- buildings energy management
- vehicle fleet management
- budgeting

Buildings energy management consists of some straightforward energy conservation measures. Temperatures might be set to approximately 68° in winter, and 78° in summer. Employees should be encouraged not to change controlled thermostat settings. Minimizing after hours use of buildings will prevent having to run heating and ventilating equipment at night and on weekends. In schools, this strategy can be particularly effective if maintenance work is rescheduled to take place in the afternoon. In addition, the simple action of turning off lights when they are not in use can save large amounts of energy, particularly if maintenance workers, often the last to leave a building, are encouraged to turn all lights off. HVAC systems should also be maintained to guarantee their operation at optimum efficiency. These options seem insignificant, but they can achieve surprising results. By implementing a program of just such conservation actions, the municipality of Oakland, California achieved a 25 percent reduction in energy use in the city's six largest buildings between 1973 and 1975.⁹

Vehicle fleet management offers many opportunities to reduce energy consumption. As vehicles require replacement, the overall fuel efficiency of the fleet can be improved by substituting cars with higher miles-per-gallon ratings. Some communities have even replaced full-size cars with scooters or "golf carts" to further reduce municipal gasoline consumption. Similarly,

trucks might be replaced by diesel-powered vehicles. School bus routes can be replanned to reduce unnecessary driving. Computerized fuel dispensing systems can prevent gas-gouging by city employees, or theft by passers-by. The effectiveness of these vehicle fleet management options is illustrated by Seattle's experience. That municipality reduced annual gas consumption by 25 percent between 1972 and 1978 by converting to smaller cars, and diesel for heavy equipment, and by monitoring gas consumption.¹⁰

One of the most effective ways to induce conservation is to simply make people aware of how much energy is being used. For many years, energy has been rolled into overhead. By making it a line item in individual departmental budgets, or by developing energy budgets for various agencies on a city-wide basis, the awareness of energy consumption is increased. Though budgeting modifications like these would be time-consuming and controversial, they provide an effective means of reducing energy use, and overall municipal spending, once implemented. Such a program could be made more palatable to department heads by making the dollars saved through conservation available for use in other areas, at the departments' discretion. In Portland, Maine, such an incentive plan for energy budget reductions was combined with an employee awareness program. Then, each quarter, in a ceremony attended by the local press and the Mayor, the City Manager awarded a plaque and a cake (decorated with candles representing the number of dollars saved) to the department that had achieved the most dramatic energy savings. At the same time, the department that had been the least successful in conserving energy was awarded a large plastic lemon. The program was so successful that projected maximum energy savings were achieved within a year.

Conclusion

Management and maintenance conservation measures outside the purview of a municipal planning board provide an important counter-part to energy-efficient planning and regulation. Regulatory measures and planning policies that support and encourage energy conservation will be more favorably received by the public if a municipality "practices as it preaches." In addition, the reduction of energy costs in a municipal budget free's up monies for other services, and buffers the community from the escalating price of fossil fuels.

FOOTNOTES

Government/Community Facilities

1. Portland Energy Conservation Choices, Volume 5, p. 12.
2. Local Government Energy Activities, Volume I, Department of Energy, DOE/PE-0015/1, 1979.
3. Ibid., Volume II, p. 23.
4. Richard G. Stein, Architecture and Energy, Anchor, 1977, p. 1.
5. Advisory Council on Historic Preservation, Assessing the Energy Conservation Benefits of Historic Preservation, Methods and Examples. Washington: U.S. G.P.O., January 1979.
6. Harwood, Using Land to Save Energy, p. 136.
7. Portland Energy Conservation Choices, Volume 3E, p. 37.
8. Local Government Energy Actions, Volume II, p. 25.
9. Ibid., p. IX-5.

Introduction

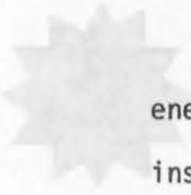
SOLAR ACCESS



The Need for Solar Access Protection

The rapid development of solar energy for space heating and domestic hot water promises to reduce this nation's dependence upon finite supplies of fossil fuels. Large investments are being made in solar technologies by both the private and public sectors. Coupled with the rising costs of oil and gas, these investments are triggering a greater utilization of solar energy. However, some serious legal and institutional barriers to the use of solar energy still remain. In particular, there is no right-to-light law in the United States and little legal support for the use of solar energy systems at the local level of government. Recent studies have emphasized the importance of developing local regulations that protect access to sunlight and permit the use of solar energy systems.¹ Regulatory solutions include amendments to zoning and subdivision regulations and the adoption of town ordinances supporting the use of solar energy systems.

Land use regulations may work against the widespread use of solar energy systems in two distinct ways. First, they may impede or prevent the installation of solar energy systems by restricting building heights, building setbacks, fence heights, accessory use heights, floor area, lot size, ground coverage, and roof projections. Second, land use regulations may not protect the solar access of a solar system owner.



Several years ago, many of these issues were hypothetical since solar energy use was a rarity. However, as oil prices have risen and solar installations have cropped up from New Jersey to Maine, many municipalities have been confronted with requests to vary zoning regulations to permit installation of solar systems in the most advantageous positions. In addition, some municipalities have recognized the need for solar access policies guaranteeing protection from possible shadows cast on solar energy systems from construction activities on a neighbor's property.

In light of the complex land use issues raised by the rapid development of solar energy, there has been a growing need for solar access guidance to planning and zoning commissions.

The specific objectives of Part II, Solar Access, are to provide such guidance by:

- explaining the need for public regulation to promote the development of solar energy and protect solar access through the master plan, zoning subdivision and site plan regulations,
- providing regulatory tools and standards for promoting the use of solar energy systems,
- providing guidelines for the development of regulations and standards to protect access to sunlight,
- identifying potential policy conflicts between the development of solar energy and other land use issues, and
- presenting practical local experiences with the development of solar access regulations.

The Need for Public Regulations

Few people recognize that solar access protection may become a serious issue as solar energy systems become more popular.² Not surprisingly, many builders, town planners and planning and zoning commissions still do not consider promoting solar energy or protecting solar access legitimate concerns to be addressed by zoning or subdivision regulation. One objection commonly raised is that builders and developers can build solar homes and design solar subdivisions even if local zoning and subdivision regulations do not address solar energy issues. The primary concern appears to be that more regulations will mean more costs to the builder - particularly builders who are not interested in constructing solar homes.

Perhaps the most convincing response to these arguments is that current local zoning and subdivision regulations do not automatically permit a builder to build a solar home or a developer to design a solar subdivision. Instead, many requirements for lot line orientation, street design, placement of street trees and protection of existing tree stands can be serious legal barriers to solar construction.

Equally important is the fact that zoning regulations and other local codes, including historic district regulations, wetland regulations, health codes and building codes, may prohibit the use of solar energy systems under certain circumstances. Some types of zoning provisions may prohibit the installation of solar energy systems or the use of passive solar design concepts in new residential developments. In many cases, it is impossible to determine the extent to which solar energy systems will be prohibited by local codes because few municipalities have explicitly referenced solar energy systems in their regulations. While the lack of specific reference to solar energy systems may or may not be a legal barrier, it is definitely a perceived barrier to the use of solar energy by many homeowners. A national poll of 2,023 homeowners conducted by the Gallup Organization, Inc. during October and

November 1980, revealed that codes and covenants which might prohibit solar energy systems were considered important or very important concerns by 58% of all those surveyed.³

Moreover, the free market is not the most enlightened means of protecting solar access or supporting the use of solar energy systems. If it were, all of the existing solar domestic hot water systems that were installed under the U.S. Department of Housing and Urban Development's \$400 rebate program would be ideal examples of proper solar access protection. However, the facts of the matter speak for themselves. Out of 153 solar domestic hot water systems inspected in Connecticut, 27% of the units were shaded or were likely to be shaded in the near future.⁴ In effect, the free market provides no guarantee that adequate solar access standards will be applied to future installations of solar energy systems.

Another objection raised by some builders is that the adoption of local regulations will only add to the cost of housing without guaranteeing any energy benefits to future homeowners. The implication is that solar access regulations offer no payback to the homeowner or to the general public. The evidence in support of solar access regulations strongly points to an opposite conclusion: that solar access regulations are an important tool for promoting energy conservation.

In fact, public protection of solar access will provide immediate paybacks to the homeowner and the community at large. Protecting against shadows from buildings, structures or trees on adjoining property protects the value of the investment made by an owner of a solar energy system. Without a public recognition of the need for solar access protection, a homeowner might install a solar collector only to find that the town has approved an application allowing their neighbor to build a multifamily housing project casting shadows on their collector. This example has actually already occurred in one Connecticut town and is likely to occur again in other municipalities unless public policy is established which protects solar access.

Finally, some builders, town planners and planning and zoning commission members that believe there is little public support for regulations encouraging or requiring the use of solar energy systems. The general perception of planners has been that any effort to promote solar access protection and the use of solar energy systems should be done cautiously. While this may be a reasonable strategy, it clearly misjudges the extent to which the general public supports the use of solar energy. The 1980 Gallup national survey of homeowners reported a startling fact: a majority of those polled (54%) indicated that passive solar design and/or solar domestic hot water should be required by law or ordinance in new home construction.⁵ The Gallup poll also revealed that of those homeowners who believe that there should be laws or ordinances requiring the use of solar energy in new home construction, nearly half prefer that they be developed at the local government level rather than at the state or federal level. These findings indicate strong public support for any municipal program geared to the promotion of solar conscious land use planning.

Requiring protection of solar access and the establishment of proper building orientation may be resisted initially by builders who have not yet understood the energy benefits derived from these principles. Nevertheless, the adoption of local regulations to protect solar access and promote solar energy is becoming increasingly important in those municipalities which are heavily dependent upon costly fossil fuels. Builders cannot continue to build houses without regard to the principles of solar access or solar orientation if the nation is to make a rapid transition to renewable energy resources. Public regulation can play an important role, especially in the early stages of the development of solar energy, by guiding the location and orientation of housing and by providing the level of solar access protection necessary for the efficient operation of the solar collectors.

FOOTNOTES

Introduction

1. See Gail Boyer Hayes, Solar Access Law: Protecting Access to Sunlight for Solar Energy Systems, Environmental Law Institute, Washington, D.C., 1979; Martin Jaffe, Protecting Solar Access for Residential Development: A Guidebook for Planning Officials, American Planning Association, Washington, D.C., 1979; and Charles Vidich, Overcoming Land Use Barriers to Solar Access: Solar Planning Recommendations for Local Communities, Central Naugatuck Valley Regional Planning Agency, Waterbury, CT, 1980.
2. The 1980 Gallup Poll pilot interview series concerning homeowners reaction to solar energy revealed that the right to light was never even raised as a possible barrier to the use of solar energy systems.
3. See Solar Age, "A National Study of the Residential Solar Consumer," p. 25.
4. Connecticut Energy Division, Office of Policy and Management, Report Domestic Hot Water System Inspections, 1978-1979, p. 2.
5. Solar Age, "A National Survey of the Residential Solar Consumer," P. 25.

Chapter 1

REGULATORY TECHNIQUES

A number of land use barriers exist which might impede the rapid development of solar energy systems. These legal and institutional barriers can be categorized as follows:

- the existence of zoning requirements which may prohibit the installation of solar energy systems under certain circumstances
- market barriers to the retrofit application of solar collectors created by past development patterns
- institutional barriers to the proper orientation of future streets, lot lines and houses created by the administration of subdivision regulations and the lack of energy policies in the town's master plan
- solar access barriers created by a lack of federal, state or local laws establishing a right to sunlight for solar energy systems.

These four barriers share a common root: all are influenced by the policies and practices of local planning and zoning commissions. A closer examination of these four broad issues within the context of the town master plan, zoning ordinance and subdivision regulation will provide a clearer understanding of the role that a planning and zoning commission can play in protecting solar access and promoting the utilization of solar energy. However, before a planning and zoning commission considers changes to its zoning or subdivision regulations, it must address solar energy and energy conservation issues within the master plan; these activities are covered in Part I, Energy Planning.

Some of the significant solar access issues that should be addressed within an energy conservation plan element are:

- the extent to which the town wishes to protect solar access as a public resource
- locations where solar energy systems should be encouraged or required by virtue of favorable slopes and solar access
- the energy savings created by establishing "solar conscious" street, lot line and building orientations
- the impact of promoting the rapid utilization of solar energy upon the energy self sufficiency of the community
- the impact of current policies contained in all elements of the Town Master Plan (but especially the land use, circulation, conservation and housing elements) on the future use of solar energy and other renewable resources.

Zoning is probably the most effective tool for promoting the use of solar energy systems because it can provide a comprehensive townwide or regionwide approach to the protection of solar access, the use of solar energy systems and the development of energy efficient patterns of development. No other local commission influences the long term energy consumption patterns of a community as much as the zoning commission. By virtue of progressive land use policies for solar access and solar energy utilization, a zoning commission can effectively expand the long term market for the use of solar energy to any degree it wishes.

In order to promote solar energy for space heating and domestic hot water purposes, a zoning commission should become familiar with:

- the existing barriers to the installation of solar energy systems contained in the zoning regulation
- procedures for requiring or encouraging the use of solar energy systems which will assure access to sunlight over the useful life of the solar energy system
- land use regulations which conserve energy thereby making it easier to use solar energy to meet a substantial fraction of a community's energy needs

These three issues should be addressed within the energy conservation plan element of the town master plan so that all local land use commissions are guided by a comprehensive and consistent solar energy plan for the town.

Energy-conscious land use planning is to some degree a return to earlier principles of land planning when solar energy and other renewable energy resources played a more critical role in the location and shape of urban development. Siting houses to take advantage of the sun is certainly not a new idea. However, "solar conscious" site planning has taken on several new dimensions with the advent of zoning and subdivision regulations as land use tools for controlling the location and intensity of urban development. Today, the long term opportunities for the use of solar energy are intimately related to the regulations and policies of local zoning commissions.

- Eliminate Legal Barriers

The first task that should be undertaken by a zoning commission is the elimination of possible barriers to the installation of solar collectors. There are a variety of situations in which zoning regulations could thwart the installation of a solar collector or the design of a passive solar home. For example:

- restrictive setbacks for rear, side and front yards could prevent a homeowner from installing a collector in his/her yard
- lack of provisions exempting solar collectors from maximum building heights could restrict rooftop installations
- accessory use regulations applied to solar collectors could prevent a homeowner from installing solar collectors in front, side or rear yard areas
- regulations governing the height and maximum ground coverage of accessory structures could be applied to solar collectors thereby limiting their size and location
- lack of yard projection exemptions for solar collectors or solar shading devices could interfere with the proper design of passive solar homes
- requiring the use of a central heating system utilizing fossil based fuels to heat all portions of a building could eliminate the energy benefits of a solar greenhouse
- establishing minimum floor area requirements may unnecessarily increase the size of the house thereby increasing the cost of home heating

- the existence of outdated regulations restricting the habitation of floor area located below grade could reduce opportunities for utilizing the earth for heat storage
- glare, lighting and reflection standards could be use to prevent the installation of solar energy systems under certain circumstances
- lack of definitions for solar technologies and solar access could pose problems in regulating solar energy systems

Perhaps the most frequent corrective action to eliminate legal barriers to the use of solar energy systems has exempted solar collectors from the maximum height limitations applied to buildings. The County of San Diego, California; Del Mar, California; Albuquerque, New Mexico; and Madison, Connecticut have all adopted amendments allowing solar collectors to be exempted from the maximum building height standards in their jurisdictions. Sample solar access ordinances, zoning and subdivision amendments can be found in Part IV, Resources.

In contrast, the most common type of zoning variances granted to homeowners wishing to install solar energy systems has permitted solar greenhouses and collectors to be located in required side, rear or front yard areas. The proliferation of this type of zoning variance suggests that zoning regulations be amended to allow installation of solar energy systems in required side or rear yard areas.

- Solar Energy Use Districts

A zoning commission must not only consider the extent to which local regulations impede the use of solar energy systems but the extent to which the commission wishes to promote the use of solar energy. The boldest steps to encourage solar development have been taken in California. For example, the county of San Diego, California now requires that all new dwelling units include solar domestic hot water systems as the primary means of heating hot water.¹ In addition, several California municipalities and counties require "solar conscious" street, lot and building orientations for new development. Some even require all existing dwelling units to be retrofitted with a solar domestic hot water system when they are sold.

A zoning regulation which requires the installation of solar energy systems for space heating or domestic hot water should be supported by solar access studies contained within the energy conservation plan element of the town master plan. The energy conservation plan element should determine the feasibility of solar energy for space heating and domestic hot water and the practicality of using solar energy compared to conventional fuels. It may not be feasible to mandate the use of solar energy for space heating if existing patterns of development are in conflict with the protection of solar access. For example, urban areas with high density development may find that mandated solar energy application is simply not feasible because of insufficient access to sunlight for most dwelling units.²

It may not always be practical to mandate the use of solar energy for space heating and domestic hot water if conventional fuels are still economical based on a life cycle cost analysis. However, it may be possible to mandate the use of solar energy in certain places within a community if a zoning commission determines that a particular area can make use of solar energy at a cheaper cost than conventional fuels. Utilization of solar energy for space heating and/or domestic hot water can be mandated in varying degrees depending upon the importance a local community places upon the development of its renewable energy resources.

At one extreme a zoning commission can mandate the use of solar energy in new buildings simply by requiring energy-efficient street and building orientations. A house facing south automatically utilizes the sun for space heating to a greater extent than a comparable house facing east or west. At the other extreme, a zoning commission can mandate the use of solar energy in new buildings by requiring that solar energy systems (whether they be active or passive) be the primary means of space heating or domestic hot water heating. This latter approach should be considered only if the commission determines that the new requirements are practical in terms of cost, and feasible in terms of solar access.

In delineating areas where solar energy systems may be required it is important to assess the quality of solar access in different parts of the community. Where land is predominantly flat or on southern slopes, the zoning commission might place greater emphasis on the promotion of solar

energy systems than on north-facing slopes. The American Bar Foundation suggests the creation of two distinct solar energy use districts which could be superimposed upon the existing land use districts of the town:

1. Mandatory solar energy use districts could be established where solar access is favorable and where passive or active solar energy systems can be installed in a cost effective manner as the primary energy source for new structures. In a mandatory solar energy use district the zoning commission would provide a greater level of solar access protection than in other areas of town through the required use of solar easements in new developments and the possible public purchase or condemnation of solar skyspace for actual, proposed or designated solar energy collectors. Mandatory solar energy use districts would be delineated on a consideration of topography, vegetation, height, bulk and location of existing structures, and the degree of solar access protection afforded by the existing zoning regulations for building heights and setbacks.
2. Discretionary solar energy use districts could be established where conditions are suitable for the use of solar energy systems, but where solar access is less easily protected or where mandatory use of solar energy systems may be impractical given the topography, vegetation, height, bulk and location of existing structures and the degree of solar access protection afforded by the existing zoning regulations for building heights and setbacks. Discretionary solar use districts might not require the use of solar energy systems, but could require that future roads, lots and houses be oriented in a manner consistent with the long term development of solar energy systems.³

The adoption of solar energy use districts would require an extensive examination of the topographic, vegetative and zoning constraints to the use of solar energy systems prior to the delineation of the boundaries of the solar energy use districts. Variances within the use districts could be granted in cases where site specific conditions prevented the use of solar energy.

● Density Incentives

Even if a zoning commission is legally empowered to mandate the use of solar energy under certain circumstances and in certain areas of the municipality, it may often be better to provide incentives for the utilization of solar energy rather than to mandate its use. For example, density incentives offered to a developer may stimulate greater building

activity, as well as providing for greater utilization of solar energy. An incentive approach also offers an effective way to reduce the potential housing cost impact that a mandatory solar energy regulation might create.

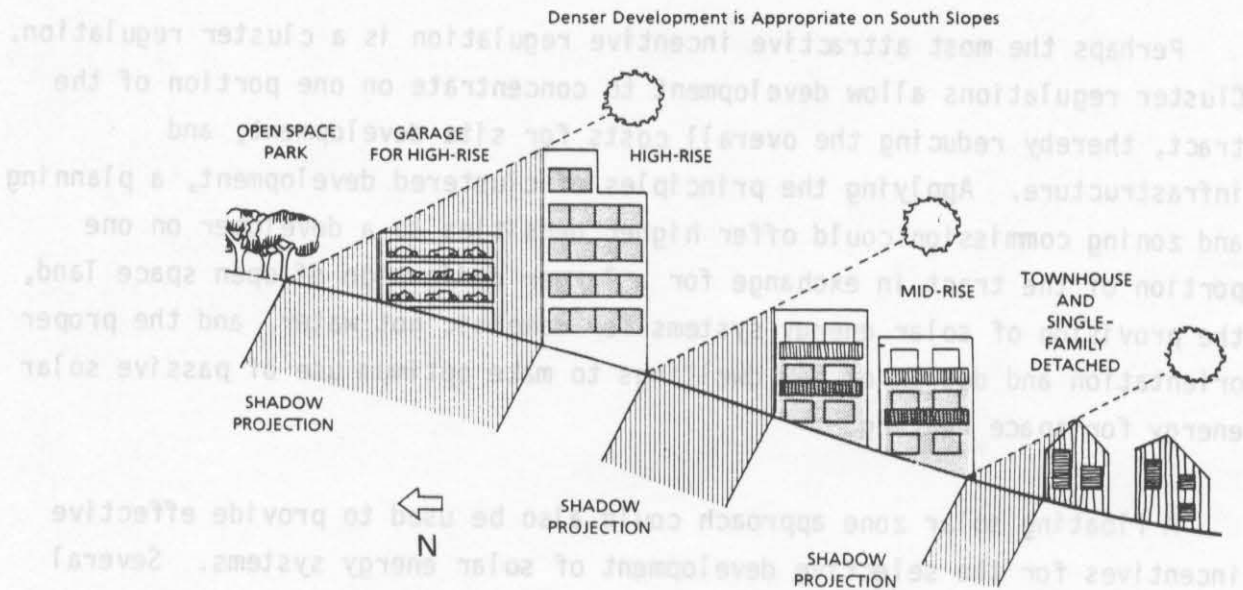
Perhaps the most attractive incentive regulation is a cluster regulation. Cluster regulations allow development to concentrate on one portion of the tract, thereby reducing the overall costs for site development, and infrastructure. Applying the principles of clustered development, a planning and zoning commission could offer higher densities to a developer on one portion of the tract in exchange for a larger dedication of open space land, the provision of solar energy systems for domestic hot water, and the proper orientation and design of new dwellings to make optimum use of passive solar energy for space heating.

A floating solar zone approach could also be used to provide effective incentives for the selective development of solar energy systems. Several criteria could be used in evaluating the suitability of establishing a floating solar zone including:

- the orientation and slope of the land
- the degree of vegetative cover
- proximity to structures which could cast shadows upon collectors, and
- the proposed utilization of solar energy systems in the new development.

Assuming a developer is able to meet all of the criteria for establishing a floating solar zone, the zoning commission could grant an increase in density which would offer sufficient incentive to make the proposed regulation financially attractive. From the standpoint of optimizing the use of solar energy within a community it would behoove a zoning commission to offer higher density development on steeper-sloped land. If this were done, single family dwelling units could be located on flat land and multi-family, mid-rise and high-rise structures could be located slightly higher up on south facing slopes, thereby reducing the shadow projection distance of these structures. (See Figure 1-1.)

FIGURE 1-1



Source: M. Jaffe and D. Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 41.

● Subdivision

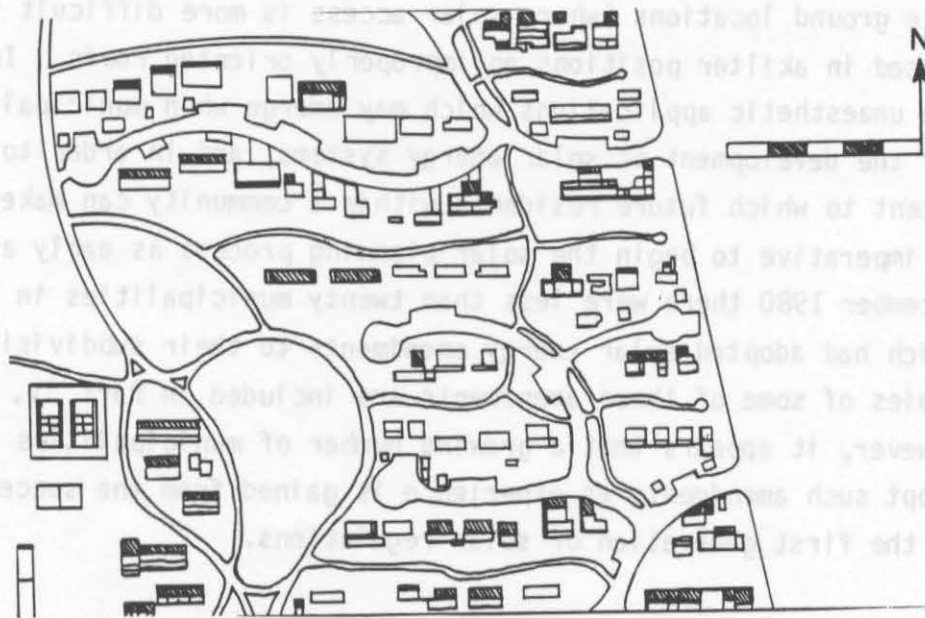
The principal advantage of incorporating solar orientation considerations into subdivision regulations is that future development can be sited in a manner consistent with the long term development of solar energy. In effect, the future development of solar energy depends upon the site planning practices being carried out by builders and developers today. If buildings are not oriented properly, then the future market for solar energy systems will be adversely affected. According to a recent survey in Connecticut, past development patterns have largely overlooked solar access and solar orientation considerations. In 1970, only 11% of all the roofs of buildings in Southbury, Connecticut, 13% of those in Woodbury, Connecticut, and 26% of those in Cheshire, Connecticut were oriented within 15 degrees of true south. These past development patterns raise two problems. First, some homeowners will be unable to effectively use solar energy in the future because of improperly oriented roofs and south walls. Second, when future homeowners

choose to install solar energy systems, those systems will either be forced to take ground locations (where solar access is more difficult to protect) or be placed in awkward positions on improperly oriented roofs. In order to avoid the unaesthetic applications which may emerge when municipalities fail to plan for the development of solar energy systems, and in order to increase the extent to which future residents within a community can make use of solar, it is imperative to begin the solar planning process as early as possible. As of December 1980 there were less than twenty municipalities in the United States which had adopted solar energy amendments to their subdivision regulations; copies of some of these amendments are included in Part IV, Resources. However, it appears that a growing number of municipalities are likely to adopt such amendments as experience is gained from the successes and failures of the first generation of solar regulations.

● Street Orientation

A southern orientation is one of the prerequisites for the effective use of solar energy systems. If a building is not oriented with its longest axis facing south, it may not be feasible to make use of the south wall or roof of the building to collect solar energy for space or water heating. Significantly, building orientation often depends upon street and lot line orientation, especially in higher density developments where the street orientation strongly influences the ultimate location and orientation of the building. Traditionally, planning commissions have been concerned with developing street systems which tie into the existing street network, while at the same time harmonizing with the topography of the land and avoiding construction upon wetlands and other unbuildable soils. In a solar subdivision, these basic planning considerations remain, but an additional item must be kept in mind. The orientation of the proposed street system must facilitate the subdivision of lots and the placements of houses which will have adequate access to the sun. Insofar as is practicable, planning commissions should consider street orientations which foster the development of properly oriented streets, lot lines and houses. (See Figure 1-2.)

FIGURE 1-2



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 89.

Streets which are constructed along an east-west axis should have little trouble in accommodating passive solar dwelling units. On an east-west street, the longest axis of the dwelling unit is easily placed parallel to the street thereby ensuring a conventional appearance to the overall design of the neighborhood while at the same time providing for the optimum southern orientation of dwelling units. Establishing a street orientation standard is desirable since it can have a dramatic impact on the public acceptance of solar subdivision design. However, a mandatory street orientation standard may not be necessary, especially for municipalities accustomed to the varied topographic conditions found in the northeast. Moreover, a mandatory standard might be unreasonable in light of the influences upon land design of such factors as slopes, wetlands, soils, and existing street patterns.

Consequently, the best approach is to establish a street orientation standard requiring streets to be constructed along an east-west axis with acceptable deviations of 30 degrees to the north or south of true west only when there are no topographic contrast and no limitations created by the existing street system. This approach provides for specific street orientation standards without unduly burdening the developer in those circumstances where street design is largely dictated by topography.

● Lot Line Orientation

In those cases where roads cannot be properly oriented along an east-west axis, planning commissions can offer greater flexibility in the delineation of side lot lines in order to allow lots to be oriented to the south. This technique provides a greater degree of control over vegetation and objects directly to the south of the house thereby offering greater solar access protection (see Figures 1-3 and 1-4.)

FIGURE 1-3

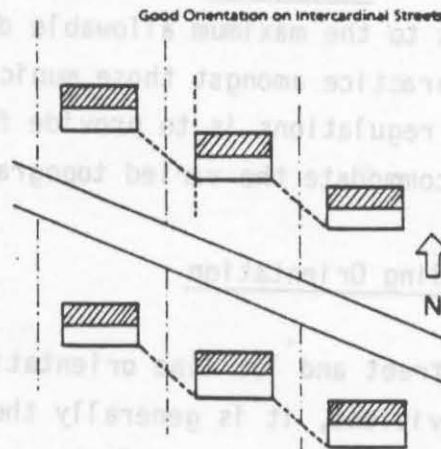
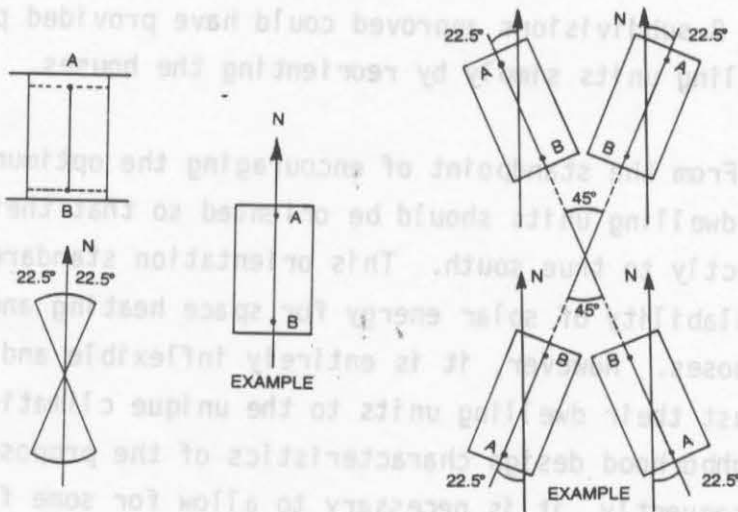


FIGURE 1-4 Sacramento County, California, Lot Orientation Criteria

A STRAIGHT LINE DRAWN FROM A POINT MIDWAY BETWEEN THE SIDE LOT LINES AT THE REQUIRED FRONT YARD SETBACK (POINT A) TO A POINT MIDWAY BETWEEN THE SIDE LOT LINES AT THE REQUIRED REAR YARD SETBACK (POINT B), IS ORIENTED TO WITHIN 22.5° OF TRUE NORTH.



ANY RESIDENTIAL LOT ORIENTED WITH THE 45° ARCS ILLUSTRATED IS CONSIDERED TO MEET THE REQUIREMENTS FOR SOLAR ORIENTATION.

Source: Jaffe and Erley, Protecting Solar Access for Residential Development
HUD/APA, pp. 90-92.

Ideally, in a solar subdivision, side lot lines should be parallel to true south, or vary by no more than 20 degrees from the north-south axis.

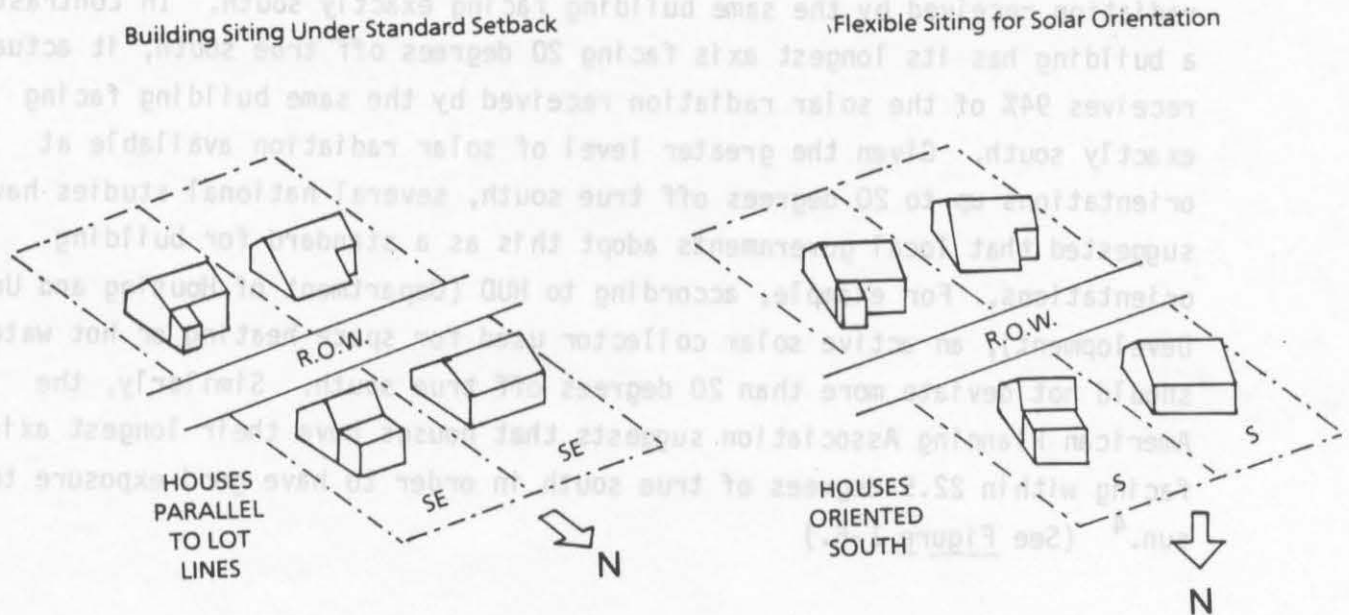
Standards for the orientation of side lot lines seem to be most important in higher density developments where house orientation can be strongly influenced by the lot line orientation. However, in low density developments it may not be necessary to impose standards for lot orientation. Indeed, the experience gathered from municipalities which have adopted solar orientation regulations indicates that, with the exception of Sacramento County, California (illustrated in Figure 1-4), none have chosen to establish quantitative standards as to the maximum allowable deviation of a lot from true south. The prevailing practice amongst those municipalities which have adopted solar orientation regulations is to provide flexibility in the delineation of lot lines to accommodate the varied topographic conditions at the site.

● Building Orientation

While street and lot line orientations offer important tools for creating solar subdivisions, it is generally the location and orientation of the house which is the most significant factor. This is particularly true in suburban and rural municipalities where low density zoning effectively offers a great deal of flexibility in the actual orientation and location of the house within prescribed setback distances. For example, in Southbury, Connecticut, of the last 8 subdivisions approved could have provided proper solar orientation for dwelling units simply by reorienting the houses. (See Figure 1-5.)

From the standpoint of encouraging the optimum use of solar energy, all new dwelling units should be oriented so that their longest axis faces directly to true south. This orientation standard ensures the greatest availability of solar energy for space heating and domestic hot water purposes. However, it is entirely inflexible and does not allow developers to adjust their dwelling units to the unique climatic, topographic and neighborhood design characteristics of the proposed development. Consequently, it is necessary to allow for some flexibility in building orientations.

FIGURE 1-5



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 72.

The principal factors which influence the selection of an appropriate building orientation standard are:

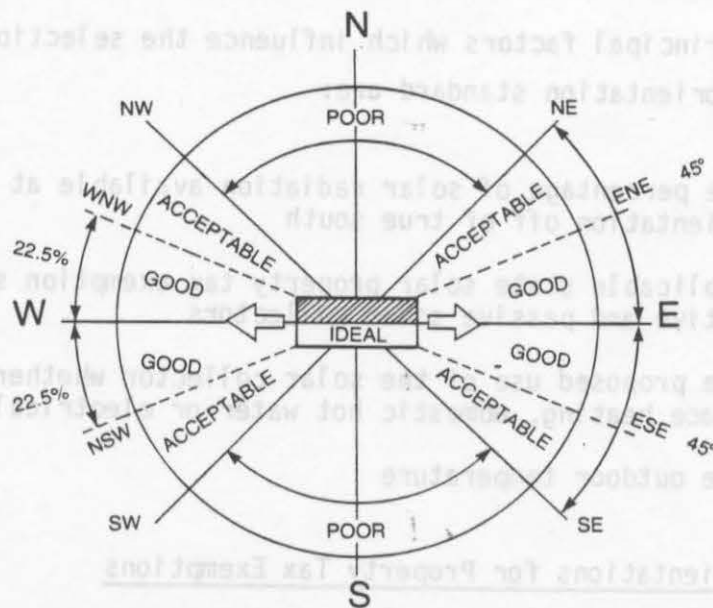
- the percentage of solar radiation available at any given orientation off of true south
- applicable state solar property tax exemption standards for active and passive solar collectors
- the proposed use of the solar collector whether it be for space heating, domestic hot water or electrical generation
- the outdoor temperature
- Orientations for Property Tax Exemptions

Perhaps the first significant factor to be considered is a state's definition of a solar energy system eligible for property tax exemptions or other such incentives. In New Jersey, for example, property tax exemptions for solar heating and cooling systems are provided under the authority of P.L. 1977 C effective July 1, 1978. In order to be eligible for property tax exemptions, In order to eligible for this exemption, a solar system should, in fact, be

oriented within 45 degrees of true south. A building which has its longest axis facing 45 degrees off of true south actually receives 75% of the solar radiation received by the same building facing exactly south. In contrast, if a building has its longest axis facing 20 degrees off true south, it actually receives 94% of the solar radiation received by the same building facing exactly south. Given the greater level of solar radiation available at orientations up to 20 degrees off true south, several national studies have suggested that local governments adopt this as a standard for building orientations. For example, according to HUD (Department of Housing and Urban Development), an active solar collector used for space heating or hot water should not deviate more than 20 degrees off true south. Similarly, the American Planning Association suggests that houses have their longest axis facing within 22.5 degrees of true south in order to have good exposure to the sun.⁴ (See Figure 1-6.)

FIGURE 1-6

Long Axis Orientation for Detached Housing



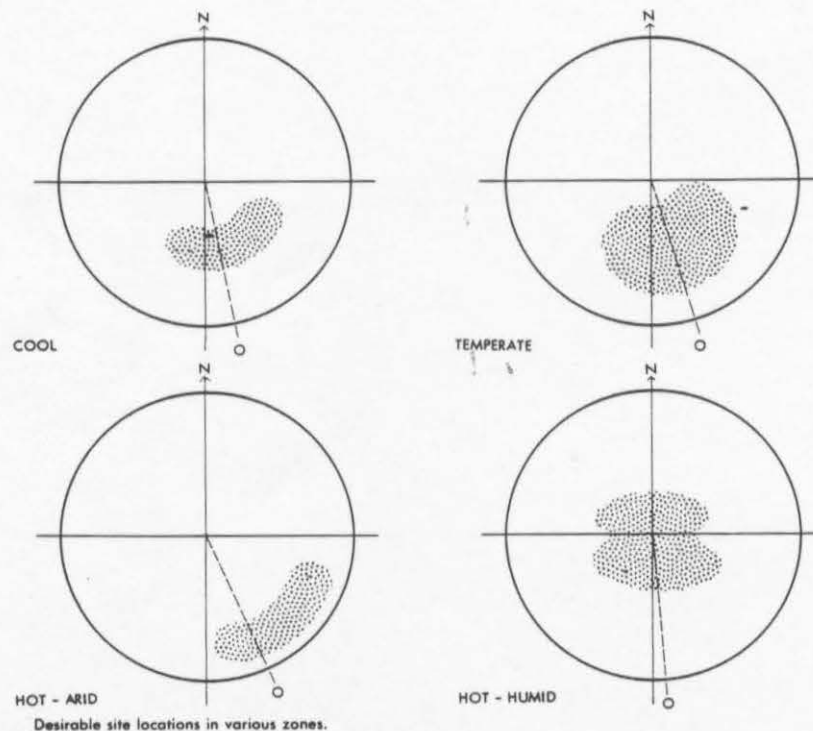
45° VARIATION FROM IDEAL EAST/WEST ORIENTATION IS ACCEPTABLE, AND A MAXIMUM 22.5° VARIATION IS BETTER, TO ASSURE PROPER WINTER HEAT GAIN AND SUMMER SHADE CONTROL.

Source: Jaffe and Erley, Site Planning for Solar Access, HUD/APA, p. 55.

• Sol-Air Orientations

While deviations either to the east or west of true south are equivalent in value from the standpoint of collector solar energy, they are not equal in terms of ambient air temperatures. Early morning temperatures are generally lower than those experienced in the afternoon. Higher afternoon temperatures, when combined with solar radiation, tend to create greater space cooling demands for houses oriented to the west. In contrast, houses oriented to the east avoid the hot afternoon summer sun and receive more early morning winter sun when space heating needs are greatest. Several municipalities have already taken solar radiation and ambient air temperatures into consideration in the formulation of what is called the sol-air orientation standard. For example, Southbury, Connecticut and Port Arthur, Texas have both established building orientation standards which encourage new buildings to face slightly to the east of true south. In the Northeast, ideal siting ranges between the cool and the temperate zones, illustrated in Figure 1-7. The overall effect of the sol-air orientation standard is to balance the need for winter space heating with the need for summer space cooling.

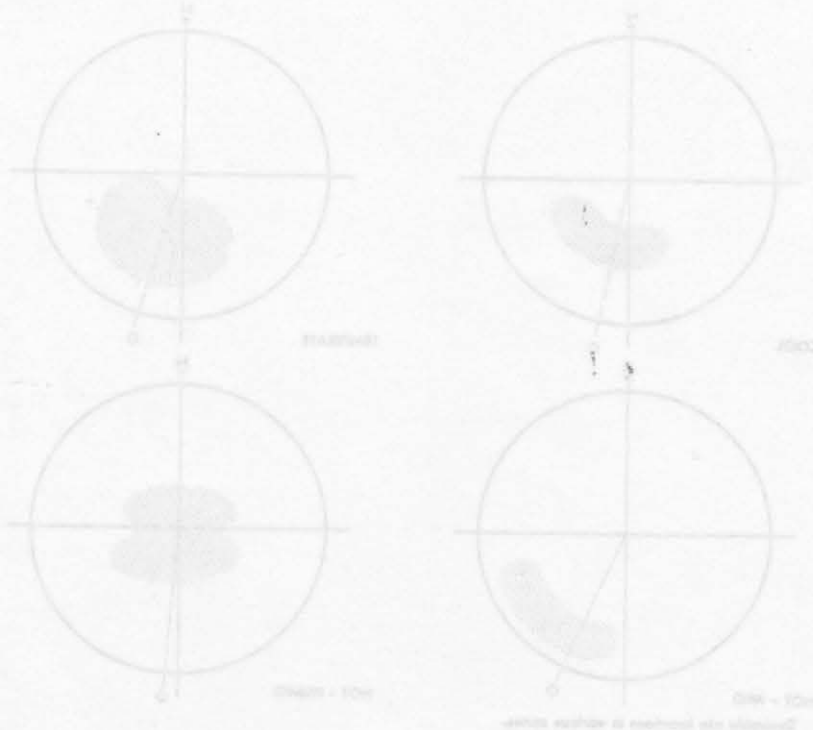
FIGURE 1-7



FOOTNOTES

Chapter 1

1. See Board of Supervisors, San Diego County, An Ordinance Relating to Plumbing to Require the Use of Solar Water Heating Systems in New Residential Construction, December 1978.
2. See Michael Shapiro, Boston Solar Retrofits: Studies of Solar Access and Economies, John F. Kennedy School of Government, Harvard University, Cambridge, MA, December 1980, pp. 24-26. An estimated one-third of all of Boston's two and three story dwelling units have good south wall solar access.
3. Allan Miller, Overcoming Legal Uncertainties About the Use of Solar Energy Systems, Chicago, Illinois, American Bar Foundation, 1979, pp. 48-51.
4. See Duncan Erley, Site Planning for Solar Access, Washington, D.C., American Planning Association, 1979, p. 55 and U.S. Department of Housing and Urban Development, Intermediate Minimum Property Standards Supplement: Solar Heating and Domestic Hot Water Systems, Washington, D.C., 1977 Edition, An Illustrated Solar Appendix, p. C11.



Chapter 2

PROTECTING SOLAR ACCESS



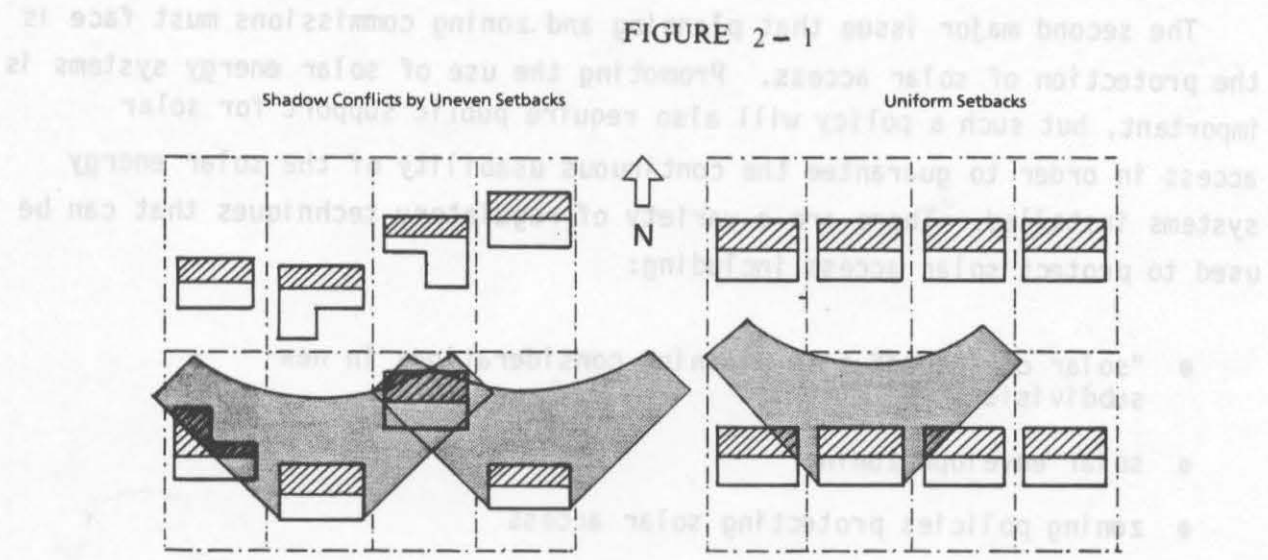
The second major issue that planning and zoning commissions must face is the protection of solar access. Promoting the use of solar energy systems is important, but such a policy will also require public support for solar access in order to guarantee the continuous usability of the solar energy systems installed. There are a variety of regulatory techniques that can be used to protect solar access including:

- "solar conscious" site planning considerations in new subdivisions
- solar envelope zoning
- zoning policies protecting solar access
- subdivision policies stipulating the use of solar easements as a condition for the approval of subdivision maps.

Solar Conscious Site Planning

Initially, the most effective means of protecting solar access is by providing for the proper location and orientation of houses in new developments. A planning commission may encourage the provision of adequate solar access to each dwelling unit by requiring developers to identify the shadows cast by objects located to the south of the proposed building. This identification of solar access problem areas can ensure that shadows are minimized at the outset of the development. Not surprisingly, several municipalities in the United States now require developers to map the shadow projections of all objects within 45 degrees of the south side of all proposed buildings. Another method of accomplishing the same objective is to require that the south walls of buildings within a subdivision receive uninterrupted sunlight between the hours of 9 a.m. and 3 p.m. on December 21st. This approach is somewhat more flexible in that it does not require the developer

to map the shadows cast by objects to the south of the collector. However, it does require that the developer locate the building so that existing and proposed buildings and vegetation do not create any shadow projections on the collector surface. In this case the burden would be on the developer to ensure adequate solar access. This approach allows the developer to determine whether tree cutting, setback of houses, or a combination of these techniques would be the best means of maximizing solar access. (See Figure 2-1.)



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 59.

Septic System Leaching Field Location

Surprising as it may seem, the location of the future septic system leaching field in developments not served by public sewers can be a significant factor in protecting future access to sunlight. In heavily vegetated areas septic system leaching fields require the cutting of tree cover in order to dig the trenches for the leaching fields. The placement of the leaching fields on the south side of the house ensures that significant shadow-casting vegetation is removed in the early stages of the development. Of course, the south side of the house may not be the best location for the placement of the septic system leaching field. The slope of the land, soil conditions and the location of the water well can also influence the proper placement of the septic system. However, whenever possible, the septic system

should be constructed on the south side as long as it does not force the developer to construct an engineered septic system to meet this requirement. The Town of Middlebury, Connecticut requires that two test pits be dug for a septic system leaching field, one of which must be on the south side of the proposed dwelling unit. This approach offers a valuable tool for combatting the most significant generator of shadows: trees and other vegetation.

Steep Slope Development

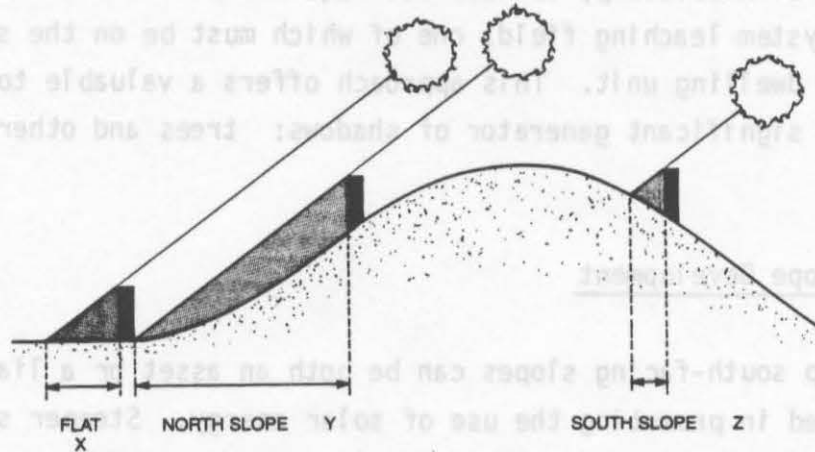
Steep south-facing slopes can be both an asset or a liability for those interested in promoting the use of solar energy. Steeper south-facing slopes offer greater levels of solar radiation per square foot than flat land, valuable windbreaks to northerly winter winds, and increased levels of solar access protection. These three factors clearly indicate that southern slopes are the equivalent of energy resource zones that can be "mined" if proper environmental precautions are taken.

In contrast, steep north-facing slopes have little value for those interested in developing solar homes or solar subdivisions. Because of the diminished level of solar radiation and increased exposure to northerly winter winds these areas are best left as undeveloped areas or turned into nature preserves or community open space land. Indeed, from both a solar access and energy conservation standpoint, it would be wise to limit new development on north facing slopes which exceed a grade of 15 percent (See Figure 2-2.)

A glance at Table 2-1 indicates that a 50 foot tree on a north facing slope of 15 percent will cast a 520 foot shadow in the morning and afternoon hours of December 21st at 40 degrees north latitude. Clearly, this shadow length can create serious problems for the protection of solar access particularly when minimum lot sizes are two acres or less. A two acre lot with its short side facing south on a north-facing slope might have 200 feet of road frontage and 400 feet of depth from the front to the rear of the lot. A 520 foot shadow length might not offer the owner of such a lot any control over his or her solar access, especially if the collector is located in the south yard, or incorporated into the south wall of the house.

FIGURE 2 - 2

Shadow Lengths Are Shorter and Higher Densities
Easier on South Slopes



DISTANCE "X" ON A FLAT SLOPE IS LESS THAN DISTANCE "Y" ON A NORTH SLOPE, FOR IDENTICAL POLES. DISTANCE "Z" ON A SOUTH SLOPE IS THE LEAST.

TABLE 2 - 1

North Shadow Projection Table

RATIO OF NORTH PROJECTION OF
SHADOW LENGTH TO HEIGHT OF
SHADOW CASTING OBJECT*

South Slope	20%	15%	10%	5%	Flat	5%	10%	15%	20%	North Slope
25°	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	
30°	1.4	1.5	1.6	1.7	1.9	2.1	2.3	2.6	3.0	
35°	1.6	1.8	2.0	2.2	2.5	2.8	3.3	3.9	4.8	
40°	2.0	2.3	2.5	2.9	3.4	4.0	5.1	6.8	10.2	
45°	2.5	2.9	3.4	4.1	5.1	6.8	10.4	21.5	—	
48°	2.9	3.5	4.2	5.3	7.2	11.2	25.4	—	—	

*These figures are approximate. At some of the higher latitudes and steeper slopes, rounding off may result in slight error. For further discussion, see Appendix III.

Source: Jaffe and Erley, Protecting Solar Access For Residential Development, HUD/APA, p. 34.

In light of the limited energy-efficiency value of north facing slopes and the fragile character of these sensitive lands, it is worth considering rezoning these areas for lower density development. Lower densities on north-facing slopes will not only protect against erosion on these lands but will serve as a long term means of reducing the town's energy consumption for space heating.

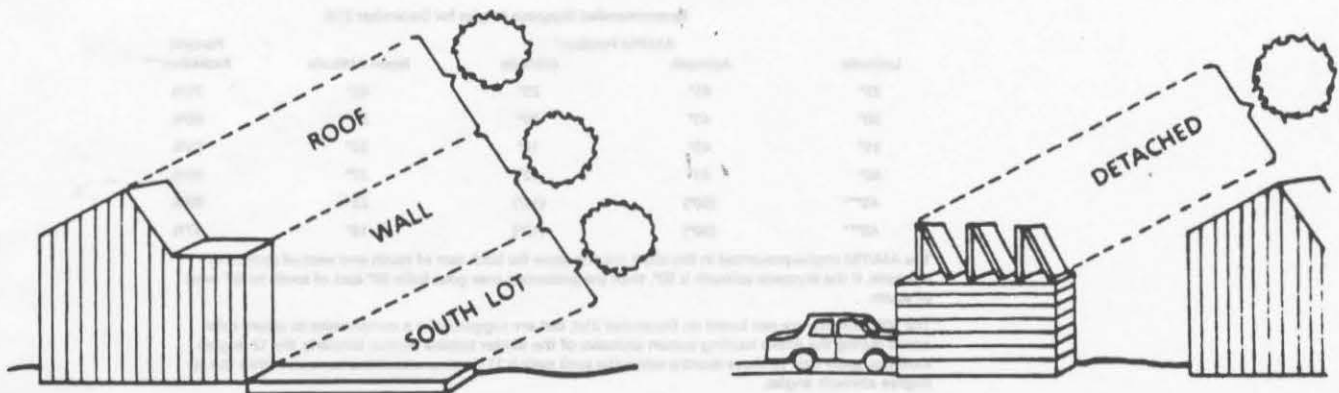
Levels of Solar Access Protection: Siting

Perhaps one of the most significant decisions that a planning and zoning commission must make is what level of solar access protection should be provided within their community. Different solar energy systems require different levels of solar access protection. For example, passive solar design applications for space heating generally require that the south wall of the dwelling unit be unshaded only during the winter months. In contrast, solar domestic hot water systems generally require year-round rooftop protection unless poor roof orientation forces a homeowner to install the solar collectors on the ground.

Wherever possible, a policy supporting south wall solar access protection should be seriously considered since it offers the long term option of using passive solar energy for space heating purposes. In light of the increasing costs of fossil based fuels and the relative importance of space heating within the consumer's energy budget it is clear that protection of the south wall is a more significant long term method of reducing energy costs for the homeowner and the community. Moreover, by protecting the south wall of a dwelling unit, a planning and zoning commission is automatically protecting rooftop solar access (Figure 2-3.)

FIGURE 2-3

Levels of Solar Access



Source: Jaffe and Erley, Protecting Solar Access for Residential Development, HUD/APA, p. 24.

Several municipalities, including Albuquerque, New Mexico and Southbury, Connecticut, have already established solar access standards. The Southbury Planning Commission has established south wall protection as the primary concern in all new residential subdivisions. Similarly, Albuquerque has adopted a zoning ordinance which prohibits any structure from casting a shadow two feet above the mean grade of the property to the north measured at the footings of the building's south wall. Copies of these regulations are included in Part IV, Resources.

Levels of Solar Access Protection: Timing

Establishing a solar access policy not only requires a consideration of the amount of the lot and building that should receive sunlight, but the amount of time that the sun would be available. It is generally not feasible - or, in fact, necessary - to protect against shadows at sunrise or sunset. Distant topographic features and nearby trees can easily shade a solar collector or south wall of a house in the early morning and later evening hours when the sun is near the horizon. At these times, the shadows cast on a collector may originate many hundreds of feet away on a neighbor's property. To control these shadows would generally lead to the confiscation of the development rights of neighboring property. Moreover, it is not necessary to have complete access to the sun. The important consideration is to have access to the sun during those critical hours of the day when the greatest level of solar radiation is available (see Table 2-2).

TABLE 2 - 2

Latitude	Recommended Skyspace Angles for December 21st		Noon Altitude	Percent Radiation***
	AM/PM Position*	Altitude		
25°	45°	25°	42°	76%
30°	45°	20°	37°	80%
35°	45°	16°	32°	85%
40°	45°	12°	27°	90%
45***	(50°)	(12°)	22°	88%
48***	(50°)	(12°)	18°	87%

*The AM/PM angles presented in this chart are the same for both east of south and west of south. For example, if the skyspace azimuth is 50°, then the protected area goes from 50° east of south to 50° west of south.

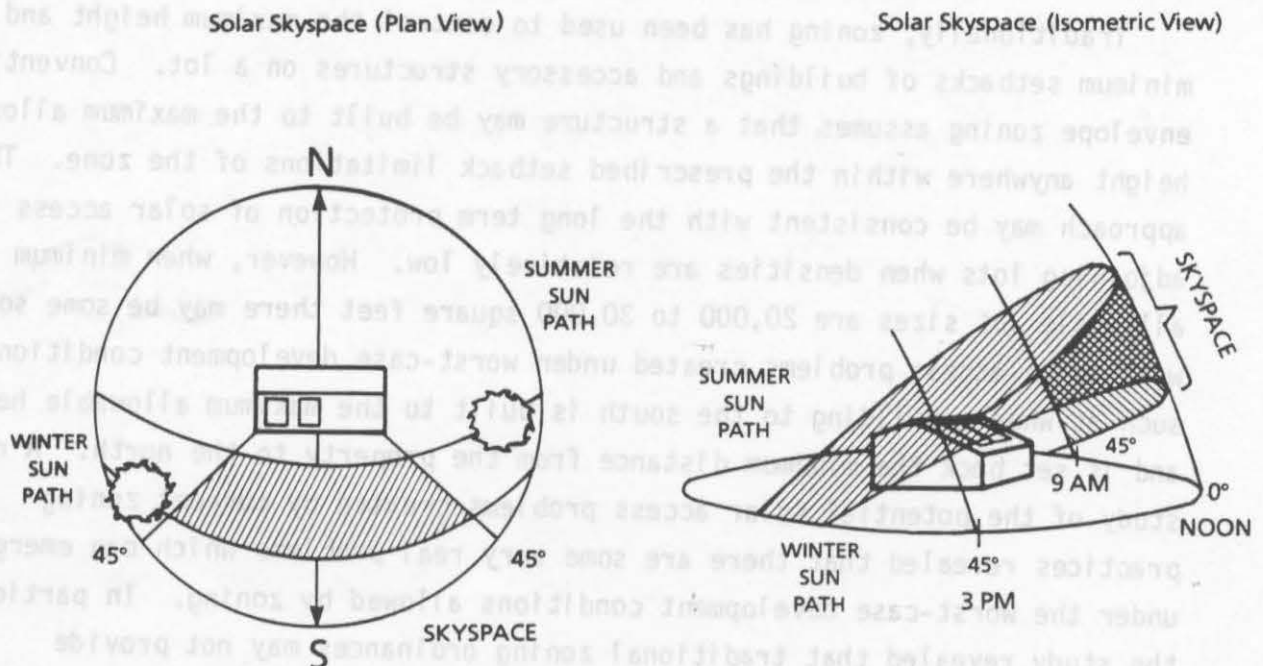
**The 50° azimuths are not based on December 21st, but are suggested as a compromise to assure solar access during the entire heating season exclusive of the winter solstice period. Similarly, the 12 degree altitudes apply only to those months when the sun's path is 12 degrees above the horizon within the 50 degree azimuth angles.

***Radiation is based on the percentage of total available radiation falling on a horizontal surface on December 21. Example: If the skyspace between 45° east of south and 45° west of south is protected at 30° latitude, then 80% of the available radiation will strike the collector. If the collector is tilted, then these percentages may be even higher.

Source: Jaffe and Erley, Site Planning for Solar Access, HUD/APA, p. 35.

Solar access should be evaluated on December 21st, since this is the time when the sun's path through the sky is the lowest on the horizon (see [Figure 2-4](#)). Generally speaking, if the sun's path is clear on December 21st then solar access is assured throughout the rest of the year. Not surprisingly, most municipalities in the United States which have established solar access standards have chosen December 21st as the day for evaluating its availability.

FIGURE 2-4



Source: Jaffe and Erley, [Site Planning for Solar Access](#), HUD/APA, P. 34.

However, not all municipalities agree on the level of solar access protection that should be offered on December 21st. Standards in effect range from 9 a.m. - 3 p.m. to 10 a.m. - 2 p.m. Essentially, these two levels of solar access protection reflect the liberal and conservative policy positions regarding the protection of solar access. The 9 a.m. - 3 p.m. standard applied at 40 degrees latitude, offers access to 90 percent of all solar radiation available on the worst day of the year. The 10 a.m. - 2 p.m. standard advocates less restrictive zoning policies for the worst day of the year since it may unduly restrict adjoining property owners or create the need for the public imposition of solar easements.

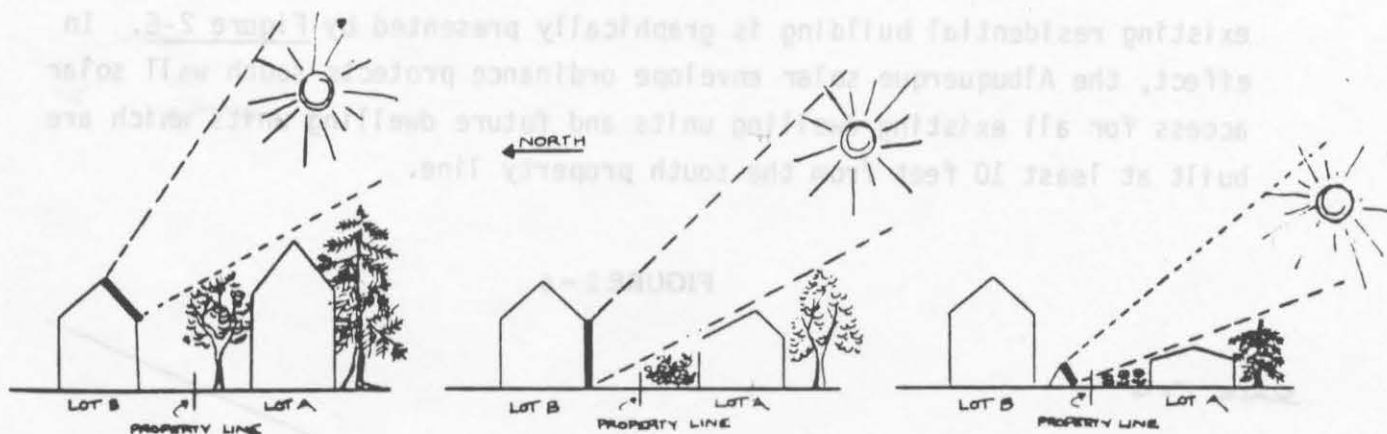
Solar Envelopes

Traditionally, zoning has been used to control the maximum height and minimum setbacks of buildings and accessory structures on a lot. Conventional envelope zoning assumes that a structure may be built to the maximum allowable height anywhere within the prescribed setback limitations of the zone. This approach may be consistent with the long term protection of solar access for adjoining lots when densities are relatively low. However, when minimum allowable lot sizes are 20,000 to 30,000 square feet there may be some south wall solar access problems created under worst-case development conditions, such as when a building to the south is built to the maximum allowable height and is set back the minimum distance from the property to the north. A recent study of the potential solar access problems created by current zoning practices revealed that there are some very real problems which can emerge under the worst-case development conditions allowed by zoning. In particular, the study revealed that traditional zoning ordinances may not provide sufficient assurances of south wall solar access when lot sizes are less than 30,000 square feet, when development is proposed on north facing slopes, or when development is proposed on a north-south oriented street.¹

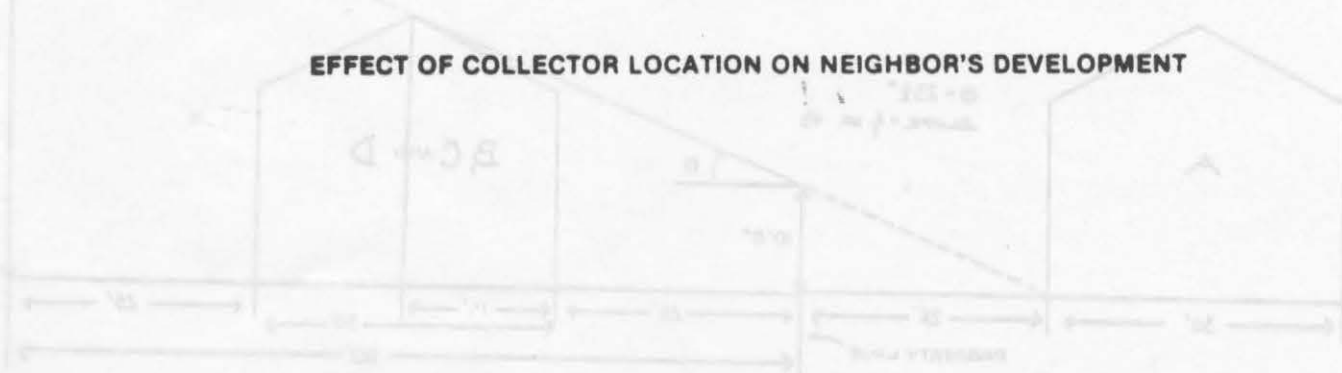
In order to compensate for some of the solar access problems associated with conventional building envelope regulations, the Environmental Law Institute recommends that solar envelope regulations be adopted.² Solar envelope regulations are intended to protect access to sunlight for solar collectors whether they are located on the south yard, the south wall or the

rooftop. The advantage of a solar envelope regulation is that it makes it a matter of public policy that no solar energy system or south wall of a dwelling unit may be shaded by a building or object to the south. As mentioned earlier, south wall protection has been suggested as the most important policy to be adopted by a zoning commission since this assures the use of solar energy for space heating or domestic hot water without unduly burdening the property rights of neighbors to the south. As can be seen in Figure 2-5, the extent of development allowed on Lot A depends upon the location of the collector on Lot B. Protecting access to sunlight for the south yard of Lot B may place too great a burden on the owner of Lot A whereas protecting access to sunlight for the rooftop of Lot B allows for a more dense pattern of development on Lot A.

FIGURE 2-5



EFFECT OF COLLECTOR LOCATION ON NEIGHBOR'S DEVELOPMENT



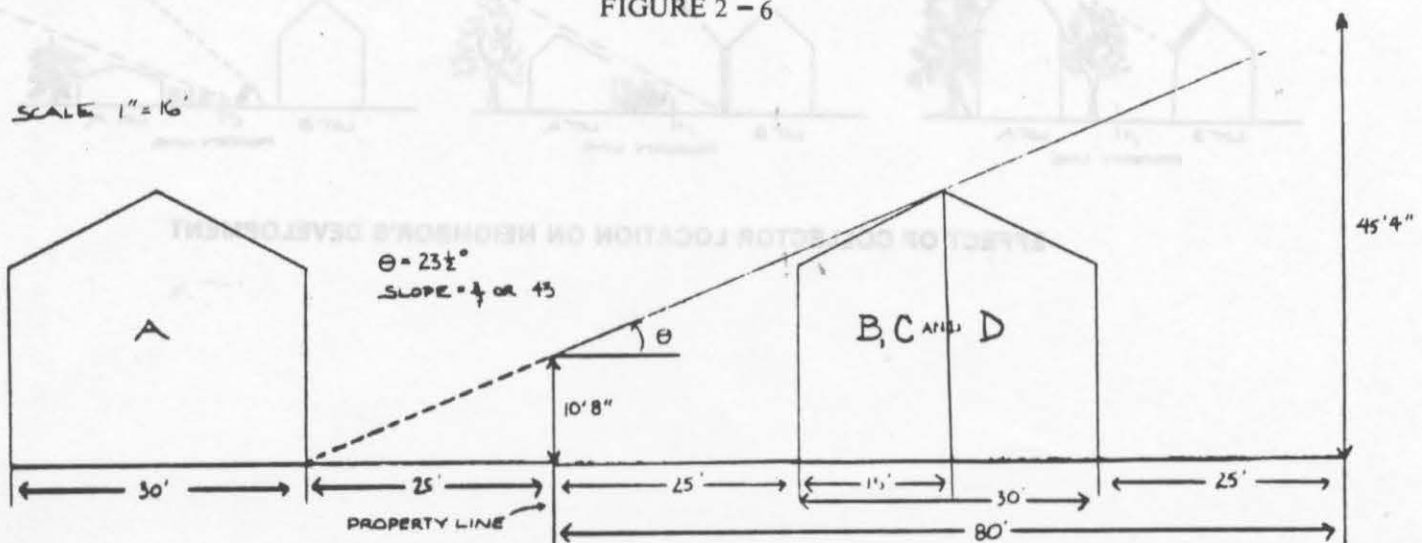
PROPERTY-LINE-BASED PLANE FOR FULL SOUTH WALL ACCESS

In its simplest form, a solar envelope could be constructed as a property line based plane extending southwards and upwards at the altitude angle of the sun at noon on December 21st. Albuquerque, New Mexico is the first municipality in the United States to have adopted this type of solar envelope regulation to control the height of future residential development. In July 1980, the City Council of Albuquerque adopted Building Height Limitations to Preserve Solar Access which requires that buildings not exceed

- "a 23 degree angle plane drawn upwards from a horizontal line located two feet above the mean grade of the facade of the principal residential building on the lot lying to the north if the lot has an existing building intended for permanent occupancy or a building permit for such structure has been issued," or
- "a 23 degree angle plane drawn upwards from a horizontal line located two feet above the mean grade of a line lying ten feet within the lot lying to the north and parallel to the general south side of the neighboring lot which is most nearly perpendicular to cardinal north, if the lot is vacant and no building permit for the structure has been applied for."

The first method of protecting solar access to the south wall of an existing residential building is graphically presented by Figure 2-6. In effect, the Albuquerque solar envelope ordinance protects south wall solar access for all existing dwelling units and future dwelling units which are built at least 10 feet from the south property line.

FIGURE 2 - 6



PROPERTY-LINE-BASED PLANE FOR FULL SOUTH WALL ACCESS

The principal objections raised against solar envelopes are listed below:

- they may constrain the development opportunities of land to the south
- they may be difficult to administer in regions with variable topography
- they may be difficult to apply in areas with north-south street patterns.

These last two problems are more common here in the northeast, where the slope and orientation of the land can vary considerably from one area of town to another. Under these circumstances, solar envelope regulations become more complex often requiring lot-by-lot evaluation of solar access.

The administrative and legal complexity of using solar envelope regulations in higher density development, on steep northern slopes and in developments with north-south oriented streets, suggests that this regulatory approach may be best suited as a district-wide approach in areas of flat land or used as a lot-by-lot approach in hilly areas along with site planning so as to minimize the inequities of a district-wide solar envelope regulation. One recent study found that density by itself need not interfere with the protection of solar access as long as special consideration is given to the placement of dwelling units to maximize solar access for the overall development. Several development scenarios achieved up to 48 dwelling units per acre without any adverse impact upon the solar access provided to each dwelling unit.³

Similarly, protection of solar access on north-south streets may also be possible. In high density developments, houses located on north-south streets will often have the roof oriented to the south rather than to the street. This pattern of development generally offers adequate solar access for the rooftop utilization of solar energy systems especially where the land is flat or sloping in a southerly direction.⁴ In low density developments, houses on north-south streets generally have both their roof and longest wall of the house facing to the street rather than to the south. This pattern of development offers adequate rooftop solar access but may not protect solar

access to the south side of the dwelling unit. One way to compensate for the limited south wall protection offered under this development scenario is by staggering the setback of the houses.

Finally, solar access protection can even be achieved even on north-facing slopes if special precautions are taken to increase lot sizes and reduce building heights. Clearly, a north-facing slope is the least likely place to develop a solar subdivision or locate a solar home. However, if slopes do not exceed 10 percent there may be an opportunity to increase lot size, lot width or depth to provide increased setbacks between solar energy systems and houses to the south. Generally speaking, north slope developments should be discouraged by increasing minimum allowable lot sizes in these areas of town. Larger lots will not only reduce the long term development of these "energy liability zones" but will ensure that when development does occur, there is a greater likelihood that solar access can be protected.

Solar Easements

After all is said about the positive features of zoning as a vehicle for protecting solar access a word of caution must be added. Zoning is subject to change. A zoning commission may decide to establish policies supportive of solar access, but ten years later decide that it is not a proper issue to be addressed by zoning. Or ten years from now the town may decide to disband zoning altogether, thereby dissolving all of its policies for solar access protection.

Should solar access protection under zoning fail, a homeowner or developer may wish to consider the use of a solar easement as backup protection. Solar easements can guarantee solar access to a solar energy system in a number of ways that a zoning regulation may not be able to do. For example, zoning regulations do not generally exercise any influence over tree heights unless those trees are a public good (such as shade trees on the street) or a public liability (such as trees which may be interfering with overhead power lines or underground utilities). In contrast, a solar easement can establish a right to unobstructed sunlight over adjoining property which will require the

adjoining landowner to prune or cut trees which protrude through the solar easement. A solar easement can also be used to limit future building development below the solar skyspace of the solar energy system, even if local zoning regulations allow for taller building heights. Clearly, the purchase of a solar easement may be expensive or prohibitive in an existing development when an adjoining landowner has no interest in cooperating.

In new developments, a planning commission can play an instrumental role in facilitating the use of solar easements by stipulating that certain lots with inadequate solar access or all lots in the development will only be approved as building lots if a solar easement is provided. The subdivision map could indicate that a solar easement is one of the conditions for the approval of the lots. The long term value of this approach is that homeowners can install solar energy systems without any fear that their collector may be subject to future shadow problems.

FOOTNOTES

Chapter 2

1. C. Vidich, Overcoming Land Use Barriers to Solar Access: Solar Planning Recommendations for Local Communities, Central Naugatuck Valley Regional Planning Agency, pp. 71-80.
2. G. Hayes, Solar Access Law, Environmental Law Institute, Washington, D.C., 1979.
3. Ralph Knowles, Solar Envelope Concepts: Moderate Density Building Applications, Golden, Colorado, Solar Energy Research Institute, April 1980.
4. See Philadelphia Solar Planning Project Solar Access in Philadelphia, Philadelphia, PA. (Forthcoming) This study determined that 90 percent of all residential buildings in Philadelphia have rooftop solar access and 56 percent have south wall solar access.

Chapter 3

NONREGULATORY TECHNIQUES



A planning and zoning commission may be able to achieve many of its solar energy and solar access objectives without actually promulgating any new regulations. It may simply be enough to convince local builders and developers that development of local renewable energy resources is an important public policy. For example, a planning commission may wish to promulgate administrative guidelines to their subdivision regulations providing commission members with insight into the means of protecting solar access. A commission can have considerable influence upon the energy impact of a development application even without solar regulations simply by offering a "solar conscious" review of the preliminary subdivision application. Builders are aware that the success of an application sometimes rests heavily upon the informal policies of the commission. Consequently, builders may be apt to include solar energy considerations in their proposal if they feel these considerations will help sell their package.

Some municipalities and counties in other parts of the United States have already published solar access guidebooks as a means of educating local builders and developers unfamiliar with the basics of solar access and solar energy. This nonregulatory technique for promoting solar energy and protecting solar access can have a considerable impact upon local builders, developers and homeowners, and thus, on local energy efficiency. A planning commission which publishes a solar access guidebook for its municipality can also play an important role in protecting solar access for existing dwelling units, where neither a permit nor a review of their proposal would come before the planning and zoning commission. Many shading problems have emerged as a result of a lack of understanding of the principles of solar access as they apply to existing dwelling units. Clearly, a solar access guidebook addressing the unique topographic conditions, solar access considerations and

Chapter 3

development limitations established by local zoning regulations could ensure that shortsighted decisions made by homeowners concerning the location and orientation of solar collectors are avoided in the future.

A third nonregulatory technique which should be considered by planning and zoning commission is the publication of model solar easements which could be made available to builders, developers and homeowners who propose new developments, or who plan to install some form of solar energy system in new residential developments. The preparation of a standard solar easement form for all new residential developments should help eliminate potential legal problems that might emerge if homeowners or builders attempt to draft their own solar easements.

Finally, a planning and zoning commission may wish to make it a matter of policy to conduct periodic workshops for builders and developers to explain the importance of utilizing solar energy resource and protecting solar access. This approach is particularly valuable after a commission has adopted "solar conscious" zoning or subdivision regulations. Builders and developers may resist or oppose solar energy or energy conservation ordinances if they perceive that the ordinance will increase the cost of housing or increase the paper work required for processing a zoning or subdivision application. These initial objections can often be overcome through workshops and seminars that educate builders and developers to the energy conservation value achieved by the new regulations. Once the regulations are properly understood and the energy savings from the regulations is perceived, the local builders may ultimately become the strongest supporters of energy-efficient regulations.

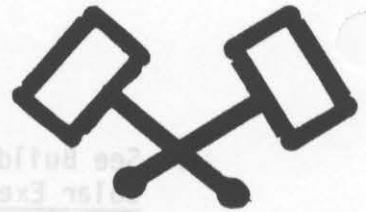
FOOTNOTES

Chapter 3

1. See Building Inspection Department, Santa Clara County, Guidelines for Solar Exemptions, Santa Clara, CA, 1980; Department of Planning and Land Use, County of San Diego, Solar Water Heating Systems Informational Guidelines, San Diego, CA, 1979; Southbury Planning Commission, Administrative Policy #6: Energy Conservation in Subdivisions, Southbury, Connecticut, 1981; Multnomah County Residential Energy Conservation Handbook, Portland, Oregon, November 1979; Addison County Regional Planning and Development Commission, Solar Commercialization in Addison County, Vermont, Middlebury, VT, 1980; and Central Naugatuck Valley Regional Planning Agency, Meeting the Energy Crisis: New Considerations for Planning and Zoning in the 80's, Waterbury, Connecticut, October 1979.

Chapter 4

POLICY CONFLICTS



Despite federal and state laws supporting the development of energy-efficient and solar-conscious land use policies, solar energy policies may not be totally supported at the local level if conflicts exist with other established policies or concerns. One of the most significant issues which has been raised in municipalities which have already adopted solar access regulations is their impact on the cost of housing. For example, at public hearings for solar access regulations held in several Northeastern towns or municipalities, residents and engineers expressed fears that the increased costs of meeting the mapping requirements for a solar subdivision might add several hundred dollars to the cost of each lot. This appears to be one of the most significant issues that a planning commission must face in developing a solar access amendment to its subdivision regulations. Increased mapping requirements must be kept to a minimum. Moreover, when mapping requirements are added they should be easily met and provide significant energy benefits to the future owner of the lot so as to justify the increased cost.

One way to avoid creating costly regulations is to evaluate the provisions of solar access regulations to determine their consistency with the "least cost housing" concept¹. Without an emphasis on a "least cost" approach to solar conscious land use regulations, the benefits of solar access and solar orientation policies may only aid those families that can afford high cost housing.

While builder reaction has generally focused on the cost of solar access regulations, local planning and zoning commission members have noted possible conflicts between solar access policies and other adopted land use policies. Solar access regulations may conflict with existing standards for:

- steep slope development
- street tree types, locations and heights
- street pattern policies
- density bonus policies
- building height limitations
- aesthetic controls over the appearance of solar homes or solar collectors

Each planning commission will undoubtedly arrive at a different balance between solar access and these existing policies. However, it appears that certain trends are emerging from the experiences of municipalities that have already implemented solar access policies.

The principal lesson that is emerging is that few municipalities are willing to alter their established policies regarding density of development in order to provide incentives to a solar developer. There are several dozen municipalities in the United States which have adopted solar access or solar orientation provisions in their zoning or subdivision regulations. However, only two or three municipalities in the United States offer density bonuses to developers who will build passive solar homes or install domestic hot water systems within new developments. In part, this early experience with solar energy regulations reveals that it is probably better to start with a modest first step at encouraging solar access protection and proper orientation of houses than to make dramatic changes in the regulations overnight.

Generally speaking, municipalities have desired to preserve existing policies for street trees, street patterns and steep slope development. However, most municipalities which have adopted solar access regulations have favored modifying existing policies on street trees, street patterns and steep slope development where it could be clearly shown that such modifications would enhance the possibility for solar energy system development and the protection of solar access. This approach allows the planning and zoning commission to maintain existing policies to address conventional developments while at the same time having the flexibility of altering the regulations to support passive solar developments.

FOOTNOTES

Chapter 4

1. See Charles Vidich, Least Cost Housing: Minimizing the Fiscal Impact of Zoning and Subdivision Regulations, Waterbury, Connecticut, CNVRPA, November 1978.

Chapter 5

PRACTICAL SOLAR ACCESS EXPERIENCES



A great deal of experience has already been gained by a number of municipalities which have adopted solar access regulations. These local experiences with solar access regulations provide valuable guidelines to other planning and zoning commissions which are about to consider "solar conscious" amendments to their regulations. Appendices 1 and 2 identify most of the municipalities and counties which have already adopted solar conscious land use regulations. These municipalities often dealt with a variety of regulatory, nonregulatory and procedural issues which can shed light upon the most suitable path for a land use commission to take when developing its community's regulations. In particular, the experience gained from developing solar access regulations in northeastern states has revealed that if a regulation is to be successful the following procedural and administrative issues should be addressed:

- holding a solar access education program for the planning and zoning commission and staff
- analyzing legal barriers to solar access in local regulations
- presenting alternative regulatory techniques for the commission to consider
- establishing public support for the regulations from the builders, citizens and key local government officials
- taking an incremental approach to the promotion of solar energy systems and the protection of solar access

Solar Access Education Program

Do not expect members of the planning and zoning commissions and even planning staffs to be conversant with the concepts of active and passive solar energy systems, solar access, solar envelopes, solar skyspace and other terms which have emerged with the advent of "solar conscious" land use regulations. One of the most important reasons for holding a solar access education program for the planning and zoning commission is that commission members are not aware of the importance of solar energy as a renewable energy resource and are not aware of the critical role that they can play in either expediting or impeding the future development of solar energy systems. An education program can be particularly successful if the program is geared to the specific solar access problems of the community. For example, the Southbury, Connecticut Planning Commission and its staff were hesitant to establish a public policy supporting solar access until the Planning Administrator reviewed the last eight subdivisions that were approved in town and found that all but one could have easily been made into a solar subdivision with minor changes in lot lines, building orientations or the location of septic system leaching fields.

One common experience found in a number of communities in the northeast has been a hesitation to adopt solar access regulations simply because such regulations are mostly being adopted in California, Colorado and New Mexico. Many commission members firmly believe that solar energy makes sense but only in western states where there is a lot of sunshine. Two things that should be mentioned in circumstances like this are:

- examples of similar communities within the state or the region which have already adopted "solar conscious" land use regulations, and
- facts supporting the greater importance of protecting solar access and promoting the use of solar energy systems in the northeast due to the higher costs of fossil based fuels, our longer and colder winters and because of the significant contributions that solar energy can make to our space heating and domestic hot water needs.

Analyze Legal Barriers

As mentioned earlier many planners and commission members may feel that local regulations do not pose any barriers to someone interested in using solar energy for space heating or domestic hot water. A review of local zoning and subdivision regulations as well as other land use codes can be quite useful since it will identify specific requirements or standards which might prohibit or impede the use of solar energy systems which might not have been identified in more general studies done at the state or national level. However, most commission members are not going to have the time to undertake such a review on their own. The planning staff for the municipality or the county should undertake this type of analysis as one of the first steps in the process of developing solar conscious regulations.

Despite the value of eliminating legal barriers to the use of solar energy systems, it appears that many northeastern municipalities are hesitant to undertake a thorough revision of their regulations in order to promote solar energy systems. This hesitation is probably due to the fact that solar energy systems have created very few land use problems. Moreover, when problems emerge they are most often dealt with simply through a variance to the regulations. Lacking any real world pressure for change, the commissions are content to believe that their zoning and subdivision regulations are not causing any problems. In addition, apparently some zoning commissions have hesitated to alter their regulations to promote solar energy systems because they fear a rash of unaesthetic "retrofit" applications of solar collectors within their community.

Present Alternative Regulatory Techniques

There is no perfect way to protect solar access or promote the use of solar energy systems. The most appropriate regulatory approach taken in one municipality may be entirely unsuitable for the municipality next door. It is important to offer alternative regulatory techniques because planning and zoning commissions may:

- have other concerns which they would like to tie into the proposed solar access regulation
- the commission members may have different viewpoints as to what are the most important priorities for local energy policy and regulation
- the commission members may want to understand the alternatives before embarking upon any one particular regulatory path.

In the Central Naugatuck Valley Region of Connecticut there are six municipalities which are considering, or have adopted, solar access regulations. Significantly, four of the six municipalities are embarking upon substantially different regulatory approaches than their neighboring towns largely because solar energy considerations have been incorporated into cluster, planned unit development or density incentive regulations which the commissions had been considering making for some time. In effect, it is often easiest to develop and adopt a solar conscious land use regulation when the commission is already considering making substantial changes to their zoning or subdivision regulations. In this case, it is simply a matter of adding an additional energy conservation, solar energy or solar access consideration to the proposed regulation.

A planning commission member in one Connecticut municipality raised serious objection to a solar access regulation on the grounds that solar energy is only one of many energy resources and only one of many renewable energy resources. His comments raise an important point that should not be overlooked by any commission or planner addressing local energy policy: the promotion of solar energy is one aspect of a larger effort to develop local renewable energy resources and reduce energy consumption. Consequently, a comprehensive investigation of all energy resources and all methods of energy conservation should be considered before drafting any specific regulations or policies.

Public Support for Local Regulations

Public support for solar conscious land use regulations is critical to the success of any efforts to adopt regulations. It was largely due to the lack of public support from the town planner and a few commission members that a Planned Solar Residential Development regulation was dismissed in one northeastern municipality. Moreover, one Connecticut municipality has taken several years to even consider solar conscious land use regulations largely because no person on the planning or zoning commissions nor any other local elected/appointed official made an effort to support the development of solar conscious land use regulations. In contrast, in Middlebury, Southbury and Naugatuck, Connecticut, solar access regulations have been quickly developed and adopted largely because a few key members on the planning commission, planning staff or local builders strongly and persistently advocated the adoption of solar conscious land use regulations. Without at least one or two committed individuals, it is unlikely that solar conscious land use regulations will be developed very quickly.

Develop Regulations Incrementally

It is not necessary to address all solar access and solar energy issues within the first regulation. Indeed, most northeastern communities which have adopted solar conscious land use regulations have focused their efforts upon one or two major concerns and agreed to address other solar energy issues as they gain experience with the newly adopted regulation. One issue that has been raised by a number of planning and zoning commissions is how far a commission should go in protecting solar access. Some commission members are hesitant to impose requirements for solar easements or solar envelopes because they are not sure to what extent, if at all, public policy should be responsible for the protection of access to sunlight to a solar collector.

In addition, planning commissions in the northeast have shied away from a mandatory approach for solar orientation of buildings and streets and the use of solar easements largely because of a feeling that such requirements might seriously raise the cost of housing or be inconsistent with an environmentally sensitive development of the land based on soils, slopes, existing street

patterns and other factors. One particularly sensitive issue that has been raised in a number of municipalities is the regulation of trees. Zoning and subdivision regulations generally have little influence over the location, type and height of trees. In the case of Southbury, Connecticut, the Planning Commission concluded that trees might not be serious threats to solar access as long as they are of the deciduous variety. Nonetheless, the Commission recognizes that evergreen trees may pose serious problems for owners of solar energy systems especially if these trees are located to the south of the solar collector.

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CITIZEN PARTICIPATION



Introduction

The goal of citizen participation is to help assure public acceptance of a local energy program. To achieve it, citizens must become an integral part of the local energy planning process from its inception through implementation. Broad participation in the decisionmaking which leads to a plan results in a commitment to local energy action by all parties that is necessary for the plan to succeed. A planning process that takes citizens' views into consideration and resolves them while the plan is in the formulation stage reduces to a minimum the level and extent of criticism that typically follows the adoption of any community-wide program. With a high degree of public support, resources can then be devoted to successful implementation of the plan, not a defense of the plan itself.

Moreover, there is evidence to suggest that in today's social, economic and political climate, citizen participation is not only desirable but also more feasible for local officials to implement than in recent history.

In his new book, public opinion pollster and analyst Daniel Yankelovich makes the observation that a trend towards self-help, localism and participation is now emerging as the nation searches for new experiences to substitute for the work-centered society that characterized earlier decades. He cites that "over the past several years, the number of Americans engaged in activities to create closer bonds with neighbors...has grown by almost 50 percent."¹

Nowhere has the trend toward local solutions to a global problem been more evident than in the area of energy. The reasons are discernible from the negative public response to repeated energy crises since the 1973 Arab oil embargo, and the resulting inability of government in years that followed to arrive at a comprehensive national energy policy. The local approach to resolving energy issues, however, has several advantages over those undertaken on a large scale: it is manageable, quantifiable, and provides the opportunity to see positive results. Unlike other issues such as crime or unemployment, energy is a subject with which the majority of local residents--whether citizens, businesses, institutions, consumer and other interest groups--can readily relate to their daily lives.

It is further in local government's best interests to provide leadership in citizen participation as a part of energy planning because of the local expertise and vigor that can be tapped, giving a flavor to the plan that is unique to the community itself.

The form that citizen participation takes will, of course, vary widely from community to community depending on its size, type of government, local resources, and a host of other variables. For purposes of this guidebook, it would not be practical to set forth a step-by-step procedure on implementing a citizen participation component to local energy planning. The actual process to be employed in any given situation is left to the discretion of the local official who is familiar with his or her own community's particular needs.

Our approach, then, is to present the principles and elements which we believe to be critical to assist local officials in formulating a successful citizen participation effort in connection with the development of an energy plan. Although some "models" are presented, they serve the purpose of translating the principles into more realistic terms for adaptation to local situations.

Managing Citizen Participation

While we have underscored the advantages of citizen participation, it is not sufficient for the planner to merely endorse it as a matter of policy. Successful citizen participation requires not only a stated commitment but also conveying a genuine interest in incorporating views of all concerned parties into the process.

It has been said the "failure to achieve effective participation may often be traced back to the lack of clearly understood and communicated definitions of what citizen participation really means."² Thus, it is important to recognize that citizen participation does not just "happen." As with local energy planning itself, it must be carefully managed to achieve the desired results.

It has also been suggested that the now familiar Management-By- Objectives (MBO) strategy has application for implementing citizen participation programs. Figure 1 suggests the five essential and related elements which shape the process:

- (1) Missions
- (2) Key Results Areas
- (3) Measures of Objectives
- (4) Action Plans
- (5) Controls

For purposes of energy planning in local government, the Missions could be re-stated as follows:

- To provide access of all segments of (community) to developing a local energy plan.
- To ensure representativeness of citizen input to the planning process.
- To facilitate local government's responsiveness to citizen input.

FIGURE 1: A MODEL MBO CHART FOR CITIZEN PARTICIPATION IN GOVERNMENT

Citizen Participation Missions	Citizen Participation Key Results Areas	Citizen Participation Measures of Objectives	Citizen Participation Action Plans	Citizen Participation Controls
To provide access to administrative decision-making	Establish two-way communication between citizen groups and the agency	# of contacts: Reach 25 citizen groups by letter or phone, by April 1, with five person-hours time. # of responses: Obtain at least 15 responses from citizen groups by April 15. # of meetings: Hold three meetings with citizen group representatives by May 15. # of citizens attending meetings: Have at least 15 citizen group representatives from at least ten organizations at each of the three meetings.	1) Obtain names, addresses, and phone #s by March 15; 2) Mail letters/make phone calls; 3) Mail follow-up letters or make follow-up calls; 4) Set initial meeting dates by April 15; 5) Procure meeting place; 6) Confirm commitments to attend meetings by May 5; 7) Reconfirm meeting time/place; 8) Identify representatives attending meetings by group.	Dept. Assistant will keep record of progress; Secretary will keep letter files/phone records; Hold staff meeting on May 16 to check status and progress; Verify that each meeting was actually held on schedule.
	Establish contact with, and provide citizen participation information to agency clients	% of identifiable clients contacted: Reach 100% of the agency's clients by letter, by April 1. % of clients expressing an interest in the program: Obtain responses from 50% of those contacted by April 10. # of clients committed to participate in meetings: Obtain commitments from 30 clients by 4/15; # of meetings: Hold at least three meetings with client groups by May 1. # of clients attending: Have at least 25 clients participate in each of the two meetings.	1) Secure list of clients by March 1; 2) Write letter to be sent requesting client participation by March 15; 3) Mail letters by April 1; 4) Mail follow-up letters if necessary; 5) Develop list of interested persons; 6) Contact interested persons; 7) Set meeting dates/places; 8) Procure meeting place; 9) Confirm Commitments to participate; 10) Record # of clients attending meeting.	Dept. Assistant will keep record of progress; Secretary will keep letter files/record of names of people to participate Verify that each meeting was actually held. If meeting was not held, reschedule as soon as possible.
	Stimulate interest in agency operations among the public-at-large	# of newspaper ads concerning public meetings: Run announcement for four days by April 10 at a cost of no more than \$400. # of people covered by ads: Reach at least 10,000 people. # of public meetings: Hold at least two public meetings. # of people attending public meetings: Have at least 100 people attend each of two meetings to accomplish all of this at a cost not to exceed \$500.	1) Place ads by April 1; 2) Procure meetings place as specified in ad; 3) Record the # of people at each public meeting.	Verify that ad appeared on stated days
To ensure representativeness of citizen input	Develop contacts with a broad spectrum of citizen groups	# of citizen groups contacted: Reach at least 25 citizen groups representative of at least 15 different interests.	1) Develop list of at least 35 citizens' groups by March 15; 2) Contact 25 of these groups; 3) Add additional groups if possible.	Complete list should be kept by the secretary Progress toward expanding list will be on file in the main office.
	Draw on the views of a cross-section of agency clients	% of clients surveyed: Reach at least 50% of clients randomly by mail survey, by April 15.	1) Obtain list of clients' phone numbers; 2) Randomly select 50% by March 15; 3) Conduct survey; 4) Tabulate results.	Secretary should have list by March 1; Random sample should be available after March 15; Project director will keep running record of survey progress.
	Identify the views of a representative cross-section of the public-at-large	% of citizens surveyed: Reach 10% of the citizens in a sample survey by April 1. # of administrative issues in the survey: Address at least six major issues, cost for all of this not to exceed \$5 per respondent.	1) Contact local consulting firm; 2) Contract to conduct survey by March 1; 3) Meet with representative of firm to set survey questions by March 15; 4) Obtain tabulated results by May 1.	Contract should be signed and on record by 3/1; Questionnaire should be designed by March 17; Project director should confirm completion of survey by April 1; Tabulated results should
To facilitate agency responsiveness to citizen input	Identify and specify substantive areas open to citizen input	# of administrative procedures open to revision: Specify by May 1, three major procedures that could be changed; # of alternative modes of operation to choose from: Specify at least three major alternative procedures that could be established.	1) Locate problematic current 2) Analyze impact of alternative procedures by March 15; 3) Narrow down alternatives to those with acceptable impacts; 4) Present alternatives at meetings.	Problematic procedures should be clear after initial citizen group and clientele meetings. Impact analysis should be prepared on April 1; alternatives should be described and distributed by April 15.
	Formulate substantive agency or program goals through negotiations with citizen groups	# of negotiating sessions with citizen groups: Hold at least two negotiating sessions after initial meeting. # of substantive program goals resolved: Derive three major goals with citizen group representatives by May 1.	1) Hold additional meetings by April 15; 2) Derive a clear statement of goals, as negotiated, by May 1.	Departmental Assistant should have goals on file for review by May 1; Project Director should have running record of progress in goal negotiation.
	Formulate substantive agency or program goals through negotiations with clients	# of negotiating sessions with clients: Hold at least two sessions with clients by 4/15; # of goals resolved: Derive 3 major goals with clients by 5/1.	1) Hold negotiating sessions by April 15; 2) Formulate clear statement of negotiated goals by May 1.	Negotiated goals should be available in writing in the project director's office by May 1.
	Include citizen survey responses in formulating goals	# of survey questions; Identify six survey questions to use in forming goals. % of goals resolved. Formulate 15% of goals with reference to survey responses.	1) Identify relevant questions; 2) Delineate program goals in general; 3) Attach goals to survey questions.	Program goals with associated survey; Responses should be available in the Director's office by May 1.

Source: Citizen Participation, May/June, 1981.

The remaining four elements can be revised to suit the mission statements. The Key Results Areas can be similarly re-stated, tailored to the local energy planning process. One of the vehicles for citizen participation described later in this section can be incorporated into an MBO scheme of this kind, with Action Plans and Controls devised accordingly.

The overriding criterion of a management approach to citizen participation--whether utilizing MBO or another method--is that it facilitates achievement of goals through a systematic mechanism. Citizen participation, by its very nature, is easily susceptible to becoming altered, misdirected or at worst, abandoned partway through the process. The effect of any of these occurrences would be potentially devastating to a local official responsible for energy planning because of the loss of credibility within the community.

Management Roles and Responsibilities³

As suggested above, there will undoubtedly be a committee or task force made up of citizen representatives which will serve as the vehicle for the implementation or focal point of the citizen participation effort.

Later in this section three models are suggested for consideration in developing a structure for this purpose. Because in each case, however, interaction with key local officials is essential, a discussion of their roles and responsibilities is presented below.

(a) Chief Executive. The mayor, county executive, city or town manager, chairman of the board of selectmen or other official must demonstrate his/her support for and priority attention to local energy planning to generate citizen participation. This commitment is critical not only at the outset, but as the individual with the authority to enforce implementation of programs and policies, the Chief Executive can and should lead the community to enthusiastically formulating and carrying out the plan.

(b) Energy Coordinator.* One of the Chief Executive's first duties is to designate an Energy Coordinator as the person responsible for the total administration of the local energy planning process, including coordinating citizen participation and liaison with all segments of local government and appropriate state and federal agencies.

Whether this person works full time on energy issues or not, and how much staff he or she has, will vary according to the size and situation of the community. Certainly for larger cities, a full-time Energy Coordinator, with support staff, is necessary to effectively develop and implement a local energy program. The Coordinator's office is best located in the office of the Chief Executive, for maximum coordination and implementation leverage. If this is politically unfeasible, the position should be located in a line department, such as community development, planning, or public works. The Energy Coordinator must nonetheless have a direct operating relationship to and the active support of the Chief Executive.

To reinforce the identity and importance of the Energy Coordinator's role in the municipal bureaucracy, institutional supports such as a designated energy office and printed letterhead should be considered. An established energy office space would provide a visible focus and contact point to the energy program for interested community members, as well as accommodating the ongoing efforts, frequent meetings and necessary materials and documentation the program will develop.

*The Coordinator and Planner roles are combined in one position for purposes of discussion in the following section, "Vehicles for Citizen Participation."

(c) Energy Planner (optional). This position should be considered in the event that the energy coordinator is not the representative of the local planning authority. This position will be particularly important in terms of addressing energy in the community's master plan, reviewing site plans, and the administration of the subdivision regulations and zoning ordinance from an energy perspective. In essence, the energy planner will need to play the role of a catalyst in advancing energy efficiency in all phases of the community's land planning and management responsibilities. Similarly, if a community has not yet initiated a community-wide energy program, the energy planner can and should play an instrumental role in accomplishing this. In either case, however, the role of the energy planner as that of technical advisor, facilitator and marketer is extremely critical. Clearly, the energy planner and coordinator's position will require a sizeable investment of staff time and some financial commitment, but experience has shown that the dollar return on this investment to the community can be truly significant.

Vehicles for Citizen Participation

Ways to structure the citizen participation process will vary from community to community. The following models will be useful in adopting a scheme appropriate to the size, type of government and energy concerns of any given locality.

<u>Model</u>	<u>Type of Community</u>
(a) Energy Policy Committee and Governmental Task Force	large cities and towns
(b) Energy Task Force	small cities and towns
(c) Regionwide Energy Committee	small towns and rural areas

(a) Energy Policy Committee and Governmental Task Force

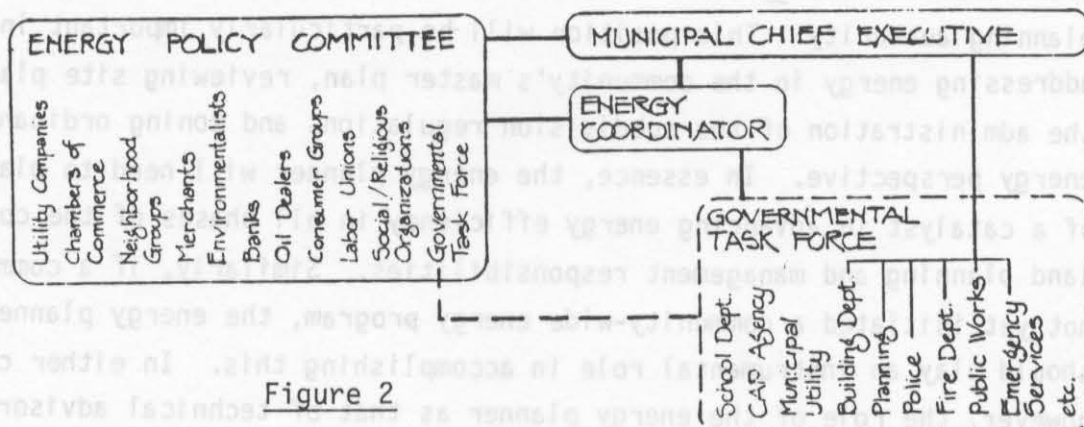


Figure 2

As seen in Figure 2 above, this model establishes a citizen-based Energy Policy Committee which interrelates with the Municipal Chief Executive, the Energy Coordinator/Planner and a Governmental Task Force consisting of all sectors of local government.

The composition of the Energy Policy Committee should be broadly representative of community interests. The categories listed in Figure 2 are indicative of the variety of organizations whose participation would be solicited. Participants at a community action workshop on local energy programs held in New England developed a still broader list of interests/constituents appropriate for involvement, loosely categorized as "private," "citizen" and "public."*

*Community Action Skills Training Workshop: Making the Transition to Self Sufficiency," Conference/Alternative State and Local Policies, September 24 and 25, 1981, West Lebanon, New Hampshire.

Private

bank
utility companies
fuel oil dealers
labor
commerce - small and
large businesses
industry - small and
large firms
trade associations
(e.g., builders,
architects)

Citizen

elderly
low, moderate
and upper income
neighborhoods by
geographic location
minorities'/women's groups
consumer groups
political organizations

Public

service clubs
(Rotary, Scouts)
churches
schools
hospitals
relief agencies
media
transportation

While the logistics involved in implementing this kind of widespread participation may seem unmanageably large, there are numerous benefits to be derived from the additional time and effort devoted to achieving it, in the form of public acceptance later on. It will be worthwhile to consider a democratic means for assuring a fair and open yet efficient procedure in which the committee will function, such as electing a chairperson, forming a steering committee and/or subcommittees and maintaining a schedule consistent with the overall management scheme.

Various resources are available to assist the Energy Coordinator in establishing and working with the Committee.⁴

As the core of the actions under consideration in the planning process, the Committee's recommendations will have significant weight in the municipal government's executive and legislative decision process.

A Governmental Task Force should be organized by the Chief Executive or Energy Coordinator/Planner to include all relevant municipal (or other local) offices or departments which influence or are affected by energy decisions, for the purpose of coordinating the planning process. This group should include the building department, public works, planning, school department, fire and police, community action agency, and emergency services, elderly affairs, or other involved agencies each municipality may have. Each agency should be represented by a senior staff person, capable of speaking for his or her department and taking responsibility for implementing actions. Such a task force is important for coordinating input and reactions to the energy

action planning and decision-making process, and for effecting the executive management decisions. It should also be linked with the Energy Policy Committee in such a way that common concerns (such as needs of elderly and low income) are communicated to the appropriate local agency or constituent via the Energy Coordinator/Planner or some other readily available and receptive means. Joint subcommittees of the Energy Policy Committee and Governmental Task Force could be established to address particularly significant issues.

(b) Energy Task Force. For smaller communities with less complex bureaucracies and interests to coordinate, the above model structure might be simplified by combining the broadly representative Policy Committee and the agency members of the Governmental Task Force into a single Energy Task Force as follows:

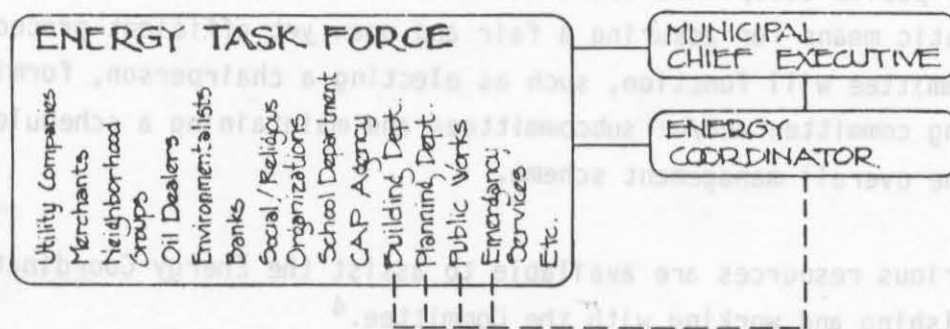


Figure 3

The Energy Task Force performs both the policy and program formulation and implementation coordination functions discussed in the previous model. In this less complex situation, the Task Force can include all key governmental departments and important outside interests, and still remain a manageable working group. The close relationship and central role of the Energy Coordinator, and committed involvement of the Chief Executive, are the same as previously described. For direct effectuation of executive energy programs and monitoring of implementation, the Energy Coordinator/Planner can deal individually with the responsible personnel in each line department.

(c) Regionwide Energy Committee. For yet smaller, more rural communities, even the above structure may be irrelevant. Because of the small size and budget of municipal government, local energy action cannot effectively be handled by the individual community. In such areas, the energy program should be run at an aggregated level - by the County Government, Regional Planning Agency, or grouping of towns. This larger scale is appropriate for consideration of many effective energy policies and actions in less densely populated areas, and the County or Regional entity is more likely to have the technical capabilities required. But the responsibility for most specific programs and executive actions still rests with the municipality, and that is where implementation of chosen energy actions must occur.

To formulate policies and programs for these situations, a Regionwide Energy Committee (covering county, planning region, or other aggregated area) should be formed which might function in a structure such as this:

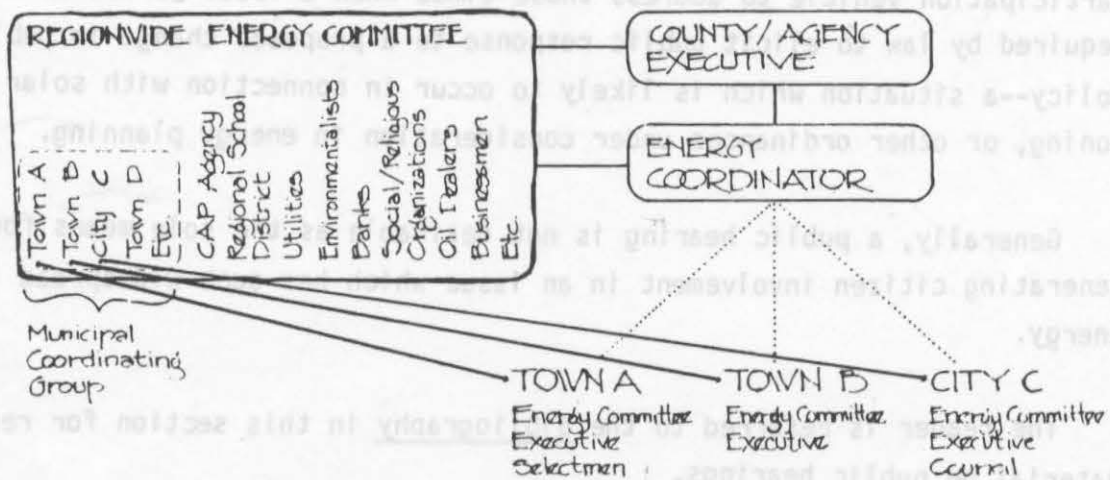


Figure 4

The Regionwide Committee includes representatives of all the constituent towns, plus special interests selected to be representative of the whole region. This Committee fills the program direction and policy formulation role of the Energy Policy Committee. The town representatives on the Committee provide liaison to their individual communities and the local program implementation, and also can function as a Municipal Coordinating Group to interrelate local efforts.

The Energy Coordinator's role remains central, in direct interaction with the Regionwide Energy Committee. The Coordinator is responsible to the County or Regional Agency Executive, if such exists for the area; but this Executive's role is less critical than on the previous models, for most implementation responsibility rests with the individual towns.

(Where no regionwide executive exists, the coordinator would be directly responsible to the regionwide committee). The Energy Coordinator would be directly involved in development and implementation of the regionwide program, and would provide a liaison and technical support role to the individual towns in their local actions to implement the regionwide energy program.

Public Hearings

The public hearing route is mentioned only briefly here as a citizen participation vehicle to address those times when a local jurisdiction is required by law to elicit public response to a proposed change in public policy--a situation which is likely to occur in connection with solar access, zoning, or other ordinances under consideration in energy planning.

Generally, a public hearing is not desirable as the sole means for generating citizen involvement in an issue which has such widespread impact as energy.

The reader is referred to the Bibliography in this section for resource material on public hearings.

The vehicles described above are considered traditional means of incorporating citizen input. We would be remiss, however, were we to overlook their drawbacks.

The following viewpoint expresses one anonymous citizen's frustration with the task force/committee vehicle:⁵

Whether it's the mayor, or a state agency or a federal department which sets up citizen participation activity, they will pick the polite, cooperative citizens who are willing to consider things from the official perspectives... They can say 'we are already taking the citizen's views into account' and brush off the ideas and criticisms of independent citizens. And even if the agency doesn't appoint the members of its citizen advisory board, it will attract the ones who are willing to 'play the game', the ones who are willing to attend meeting after meeting and review agency programs, policies and budgets.

Things would really be better if there were no such thing as an official citizen advisory board....

While it could be argued that with proper motivation and good management, citizen boards can be effective, some deficiencies are inherent and difficult to overcome, even for the most committed public official. Five pitfalls are noteworthy. Some also apply to public hearings.⁶

- (1) Ease of manipulation by public official or other responsible party.
- (2) Unrepresentativeness, no matter how "fair" the selection process.
- (3) Built-in bias likely from those who might be hurt by a policy over those who might be helped.
- (4) Lack of input from that segment of the public which is uninterested but nonetheless impacted (estimated at 99%).
- (5) "Loss in the translation" of concerns communicated by groups through their representative.

Citizen Surveys

An alternative to any of the above vehicles is the citizen survey. The primary drawback to this method is that there is no opportunity for interaction among citizens. A survey is completed in isolation and therefore the respondent does not participate in a consensus process, communicating and sharing views with others. Further, for the local official, costly expertise is often required to conduct a survey in a professional, reliable manner.

When all factors are considered and a survey is determined to be the best course of action, the following principles are offered to make it effective:⁷

- (1) Select a survey research organization that is experienced, competent and has a good track record for developing meaningful data.
Imagination and competence pay off extremely well in the design, conduct, and analysis of a survey.
- (2) The persons responsible for the policy decision should work closely with the researchers in designing the survey.
- (3) Make sure that highly qualified staff or consultants are available at completion of the survey to help interpret the information in ways that are meaningful for the decision-making process.

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Footnotes

1. Daniel Yankelovich, "New Rules: Searching for Self-Fulfillment in a World Turned Upside Down". (New York: Random House, 1981), pp. 4 & 11.
2. Kent Portney, "Management by Objectives: A Means to Effective Citizen Participation." Citizen Participation, Vol. 2, No. 5, May/June, 1981, p. 7.
3. Adapted from "Massachusetts Local Energy Program," prepared by Arrowstreet, Inc., under a grant from the Northeast Solar Energy Center as part of the Solar Cities and Towns Program of the U.S. Department of Energy.
4. See, for example, Biagi, Bob. "Working Together: A Manual for Helping Groups Work More Effectively."
5. Duane Dale, How to Make Citizen Involvement Work. Citizen Involvement Training Project, p. 7.
6. Lester W. Milbrath, "Citizen Surveys." Citizen Participation, Vol. 2, No. 4, March/April, 1981, p. 4.
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